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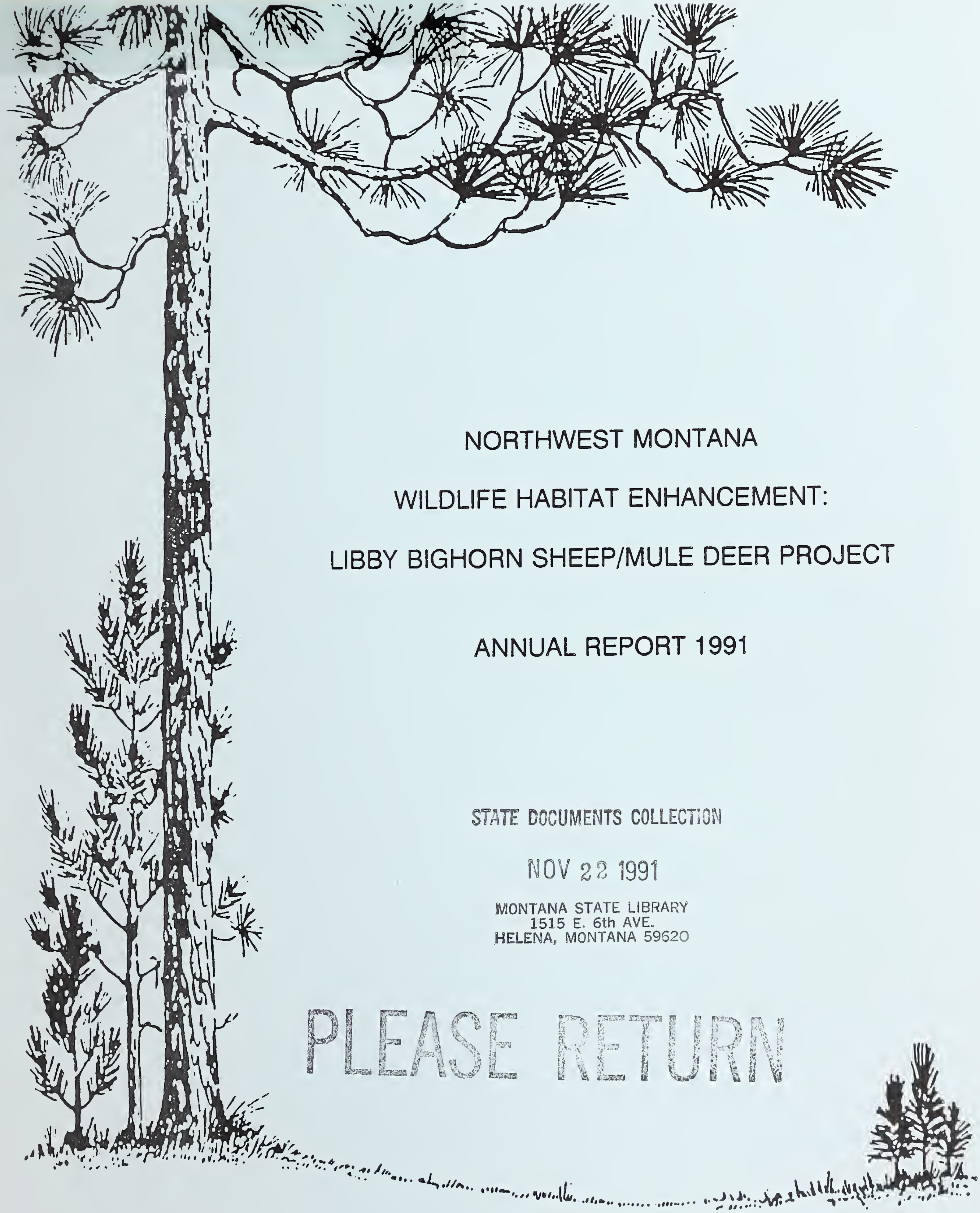

NORTHWEST MONTANA
WILDLIFE HABITAT ENHANCEMENT:
LIBBY BIGHORN SHEEP/MULE DEER PROJECT

ANNUAL REPORT 1991

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ANNUAL REPORT

NORTHWEST MONTANA WILDLIFE HABITAT ENHANCEMENT: LIBBY BIGHORN SHEEP AND MULE DEER PROJECT

Ural-Tweed Bighorn Sheep Project
Project - 5136.1

Ural-Tweed Mule Deer Project
Project - 5137.1

Ural-Tweed Wildlife Mitigation Project
Project - 5137.2

Prepared by

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June 1991

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TABLE OF CONTENTS

PAGE

EXECUTIVE SUMMARY 1

INTRODUCTION 4

DESCRIPTION OF THE PROJECT AREA 5

METHODS 10
- Wildlife Use of Treatment Areas 10
  - Objectives 10
  - Immobilization and Trapping 10
  - Marking 11
  - Animal Movements and Distribution 11
  - Habitat Analysis 12
  - Population Surveys 12
  - Mark-recapture 13
  - Big Game Hunter Check Station 13
  - Browse Utilization 13
  - Pellet Group Surveys 13
  - Fecal Analysis - Food Habits, Nutrition and Lungworm 14

- Vegetation Monitoring 14
  - Objectives 14
  - Monitoring Transects 14
  - Photo Plots 17

RESULTS AND DISCUSSION 18
- Marked Animals 18

- Population Estimates 18
  - Bighorn Sheep 18
  - Mule Deer 28

- Animal Movements and Distribution 30
  - Bighorn Sheep 30
  - Mule Deer 30

- Habitat Use 38
  - Browse Utilization 41
  - Pellet Group Surveys 42

- Vegetable Monitoring 45
  - Herbaceous Forage Production 45
  - Consultation and Coordination 50

LITERATURE CITED 52

APPENDIX A - Browse Utilization 55

APPENDIX B - Pellet Group Summaries 64

LIST OF TABLES

PAGE

Table 1. Marked bighorn sheep within the Ural-Tweed project area, 1984 to present 19

Table 2. Marked mule deer within the Ural-Tweed projects area, 1984 to present. 21

Table 3. Summary of helicopter surveys conducted within the Ural-Tweed bighorn sheep range, 1985-1990, with a population estimate based on the results of each survey. 24

Table 4. Percentage of instrumented mule deer in each movement pattern for each PHU and for all PHU's combined. 36

Table 5. Mean summer convex polygon home range sizes and average activity radii for 1988-89. 38

Table 6. Mean winter convex polygon home range and average activity radii for each PHU 38

Table 7. Relative occurrence of cover types within each PHU. 40

Table 8. Relative use of cover types and coefficients of variation (C.V.) in each PHU for summers 1988 and 1989. 40

Table 9. Relative use of cover types and coefficients of variation, by movement pattern, for summers 1988 and 1989. 41

Table 10. Summary of Chi-square analysis to evaluate use vs. availability of cover types, aspect and slope during summers 1988 and 1989. 42

Table 11. Mean elevations (m) of mule deer for all movement patterns and PHU's during summers 1988 and 1989 45

Table 12. Summary of the vegetation monitoring schedule for the Libby Wildlife Mitigation Project, 1985-1989. 50

LIST OF APPENDICES

PAGE

Appendix A Browse utilization data from treatment and paired control areas from 1985 through 1989 56

Appendix B Pellet group transects on study area analyzed from 1985 to present. 65

Appendix C Herbaceous plant production (kg/ha) on treatment and paired control areas, 1985 to 1990. 68

LIST OF FIGURES

PAGE

Figure 1. Map of the Ural-Tweed project area 6

Figure 2. Contour map of north Salish mountains study area illustrating 2 topographic zones. 7

Figure 3. BPA funded habitat enhancements and Whirlybird logging units. 9

Figure 4. Number of marked bighorn sheep, by marker type, 1984 to present 20

Figure 5. Bighorn sheep population trend, Biological Year 1984 to 1990, based on annual population estimates. 25

Figure 6. Bighorn sheep population trend, Biological Year 1934 to 1990. 25

Figure 7. Sex and age composition of the Ural-Tweed bighorn sheep population, 1984 to 1990. 26

Figure 8. Number of lambs: 100 females, Ural-Tweed bighorn sheep population, 1984 to 1990. 27

Figure 9. Number of yearlings: 100 females observed in the Ural-Tweed bighorn sheep population, 1984 to 1990 27

Figure 10. Number of rams in the four adult male categories. 27

Figure 11. Age distribution of mule deer captured on the Ural-Tweed winter range, 1987 to 1989 29

Figure 12. Age distribution of hunter harvested mule deer (HD 100) checked at the Koocanusa Bridge check station, 1987 to 1990 31

Figure 13. Age distribution of hunter harvested mule deer (HD 101 and 103) checked at the Koocanusa Bridge check station, 1987 to 1990 32

Figure 14. Three mule deer population-habitat units (PHU's) associated with the Ural-Tweed winter range 33

Figure 15. Winter and summer home ranges for 3 instrumented mule deer which illustrate ISR, ASR and DSR movement patterns 35

LIST OF FIGURES (Continued)

PAGE

Figure 16. Location of winter and summer Geographical Activity Centers (GAC) for each instrumented deer in PHU 1 37

Figure 17. Location of 5 overlapping summer home ranges for DSR deer in PHU 2 39

Figure 18. Selection of aspect by mule deer in the 3 PHU's and 3 movement patterns 43

Figure 19. Selection of slope by mule deer in the 3 PHU's and 3 movement patterns 44

Figure 20. Summaries of pellet group surveys in the treatment and control areas, 1985 to 1990 46

Figure 21. Summaries of herbaceous plant, production in treatment and control areas, 1985 to 1990 48

EXECUTIVE SUMMARY

Construction of Libby Dam on the Kootenai River in northwest Montana was completed in 1973. This hydroelectric facility inundated approximately 11,735 ha of productive wildlife habitats within the U.S. portion of Lake Koocanusa. The total includes 1,761 ha and 6,950 ha of spring and winter habitats for bighorn sheep and mule deer, respectively.

The Pacific Northwest Electric Power Planning and Conservation Act of 1980, P.L. 96-501 (NW Power Act), established the Northwest Power Planning Council (Council). It directed Council to develop a safe, efficient and reliable energy source for the Pacific Northwest and to develop a program to protect, mitigate and enhance fish and wildlife affected by the development and operation of Columbia River hydroelectric facilities, including Libby Dam.

In 1984, Council amended a measure to mitigate impacts to the Ural-Tweed bighorn sheep herd into it's Fish and Wildlife Program. It authorized Bonneville Power Administration (BPA) to fund the Ural-Tweed Bighorn Sheep Mitigation Project. The project (BPA 84-39, MDFWP 5136.1) was initiated in September 1984. Funding for the project was provided by BPA through June 1990.

In September 1987, the scope of the project was expanded to include mule deer (BPA 87-55, MDFWP 5137.1). We have conducted extensive monitoring of the mule deer population to determine seasonal distributions and habitat preferences. Mule deer responses to a variety of habitat enhancements have also been monitored. A graduate research project was conducted from spring 1988 through fall 1989. This project focused on the spring, summer and fall movements and distribution of the mule deer which winter on the Ural-Tweed range. Bret Stansberry finished his thesis in April 1991 and many of his results are incorporated into this report. Project activities are currently funded by the Wildlife Mitigation Trust Fund.

A long-term habitat enhancement project plan was developed by Kootenai National Forest (KNF) and Montana Department of Fish, Wildlife and Parks (MDFWP) personnel. This plan outlines habitat enhancement projects to be completed on winter ranges adjacent to Lake Koocanusa and the Kootenai River immediately downstream from Libby Dam. Projects in the plan will be implemented from 1989 through 2000.

Primary objectives of the wildlife mitigation projects for Libby Dam have been:

1. In cooperation with the KNF, develop a habitat enhancement plan for the bighorn sheep and mule deer winter and spring ranges. These ranges (51,000 ha) are adjacent to Lake Koocanusa and the Kootenai River immediately downstream from Libby Dam.

2. Determine changes in size and composition of the bighorn sheep and mule deer populations. Evaluate whether a one-third increase in the size of the populations was obtained because of habitat enhancement efforts.

3. Evaluate vegetation responses to a variety of habitat treatments. Data gathered during this process will help in determining changes in foraging capacity resulting from the treatments.

4. Determine if the habitat treatments result in changes in bighorn sheep and/or mule deer movements, distribution or habitat selection.

Development of habitat improvement projects has been a cooperative effort between personnel from the Kootenai National Forest and Montana Department of Fish, Wildlife and Parks (MDFWP). Implementation of improvement projects has been the responsibility of the KNF (BPA Project 84-38). Evaluation of vegetative and animal responses to habitat treatments has been completed by MDFWP personnel (BPA Project 84-39).

The FY90 annual report presented a preliminary summarization and analysis of monitoring data for the bighorn sheep population. Shrub frequency and volume data were also summarized. In this report, we focused on the mule deer distribution and population characteristics. Additional analysis of the vegetation data is also presented. Additional reports completed during FY 91 include:

Stansberry, B. J. 1991. Distribution, movements, and habitat use during spring, summer, and fall by mule deer in the North Salish Mountains, Montana. M.S. Thesis, Montana State University, Bozeman, MT. 64pp.

Yde, C. 1991. Evaluation Plan for the Koocanusa long-term habitat enhancement plan. U.S.D.E., Bonneville Power Admin. rept., Contract DE AI79 87BP36136, Proj. 87-55. 22pp.

Information presented in this report is considered preliminary and may not be cited without permission of the Montana Department of Fish, Wildlife and Parks.

INTRODUCTION

Both bighorn sheep (*Ovis canadensis*) and mule deer (*Odocoileus hemionus*) occupy the Ural-Tweed winter range. The Ural-Tweed bighorn sheep population is the last native bighorn sheep population in northwestern Montana. This population has historically occupied slopes along the east side of the Kootenai River valley from Cripple Horse Creek north to the Pinkham Divide (Brink 1941, Couey 1950, Brown 1979). Available information indicates steady population growth from the 1940's (Ensign 1937, Brink 1941) until the population stabilized in the mid 1960's. At this time, there were approximately 150-200 animals in the population (U.S. Dep. Inter. 1965). From 1965 to 1978, the population declined to an estimated 20-25 animals (Brown 1979). By the mid-1980's the population had started to recover from this low level (Yde and Olsen 1984). Population growth continued through the 1980's, with approximately 150 bighorn sheep in the population in 1990 (Yde and Coates 1990).

The Ural-Tweed range has been identified as an historical winter range for mule deer (Bergeson 1942 and 1943, Blair 1955, Brink 1941, Drumheller 1936, Zajanc 1948). In this area, mule deer typically winter along open slopes. Higher elevational ranges with areas of broken topography, such as the area between Tenmile Creek and Stone Hill, are preferred by mule deer (Zajanc 1948 and Blair 1955). These areas are above the usual winter range for white-tailed deer (*O. virginianus*) and overlap those areas used by wintering elk (*Cervus elaphus*). Estimates of the size of this population vary greatly and have little reliability because of the nature of the surveys upon which the estimates are based.

Construction of Libby Dam and impoundment of Lake Koocanusa resulted in the inundation of important winter and spring habitats for bighorn sheep and mule deer. Approximately 1,761 ha of bighorn sheep and 6,950 ha of mule deer spring and winter habitats were inundated. These habitats provided essential winter and spring range components (Yde and Olsen 1984). Inundated habitats provided nutritious forage during periods of adverse winter weather and during the important spring "green-up". With important "green-up" areas inundated by the reservoir, bighorn sheep and mule deer have been forced to use lower quality, dormant vegetation for a longer period. During the development of the impact assessment, an associated reduction in physical condition resulting in reduced reproductive success was predicted (Yde and Olsen 1984). The importance of "green-up" areas for females bighorn sheep during late stages of pregnancy and lactation has been documented (Stelfox 1976, Wishart 1978).

Ecological succession has also limited the ability of the bighorn sheep and mule deer populations to rebound following habitat loss. A series of aerial photographs (KNF files) show a habitat mosaic present throughout the range during the 1940's and 1950's. Additionally, there is as abundance of fire scarred trees in the project area. The combination of these is evidence that fire, historically, played a major role in determining habitats and habitat characteristics in the project area. Wildfire historically maintained a disclimax, open ponderosa pine (*Pinus ponderosa*) - bunchgrass community on the south and west facing slopes within the sheep range. Periodic burning also maintained forage availability and quality. With initiation of intensive fire suppression in the 1930's, the role of fire in maintaining the preferred ecological disclimax community was circumvented. This resulted in establishment of more densely forested Douglas-fir (*Pseudotsuga menziessii*) communities. Stelfox (1976) noted similar fire suppression and resulting loss of bighorn sheep habitat due to advanced ecological succession in the Athabasca Valley, Alberta, Canada between 1921 and 1953.

In accordance with the Northwest Power Act, a joint project between the KNF and MDFWP, funded by BPA, was initiated in September 1984. This project was designed to mitigate impacts of the Libby Dam hydroelectric facility and Highway 37 on the Ural-Tweed bighorn sheep population. This project has been directed at improving habitat in selected winter and spring bighorn sheep use areas. In September 1987 the mule deer portion of the project was added. With this addition, we began monitoring the characteristics and size of the mule deer population, it's seasonal and annual distribution, and it's response to the habitat enhancement efforts.

DESCRIPTION OF THE PROJECT AREA

The project area is located along the northwest flank of the Salish Mountains, approximately 48 km northeast of Libby, Montana (Fig. 1). Encompassing approximately 446 km^2, the area includes portions of the Rexford and Fisher River Ranger Districts, Kootenai National Forest. Boundaries are the Pinkham Creek Divide on the north and east, Fivemile Creek on the south and Lake Koocanusa on the west. Elevations range from 750 m at the full pool level for Lake Koocanusa to 2,142 m at the top of McGuire Mountain.

Topographic features of the study area can be separated into two components (Fig. 2). From the lake level to approximately 1,525 m, the area is characterized by very steep, broken terrain, including steep cliff faces and talus slopes. The diversity of the terrain is conducive to mesic microsites, where green vegetation persists throughout the summer. Often this green vegetation is present into the fall. On Stone Hill, this steep, broken pattern holds, but the area is terraced. Several of the terraces are mesic and sustain lush vegetation longer than the adjacent area. Above 1,524 m, the terrain becomes less severe with more gentle slopes extending to the ridgetops. These gentle slopes lack the topographic variation of the lower slopes. This results in fewer mesic sites within this zone.

A variety of timbered habitats cover the majority of the project area. The primary commercial use of the area is timber production. Limited livestock grazing does occur on portions of the project area.

Using strata maps (U.S. Forest Service files), which show the existing vegetative conditions, we categorized the area into four major coniferous cover types. These cover types are:

Ponderosa pine / Douglas-fir type. This type occurs along the lake shore upwards to an elevation of about 1,035 m. Ponderosa pine is the major overstory species with Douglas-fir usually found throughout. Common shrubs include common snowberry (*Symphoricarpos albus*), Saskatoon serviceberry (*Amelanchier alnifolia*), rose (*Rosa spp.*), and bearberry (*Arctostaphylos uva-ursi*). Bluebunch wheatgrass (*Agropyron spicatum*), rough fescue (*Festuca scabrella*), and pine grass

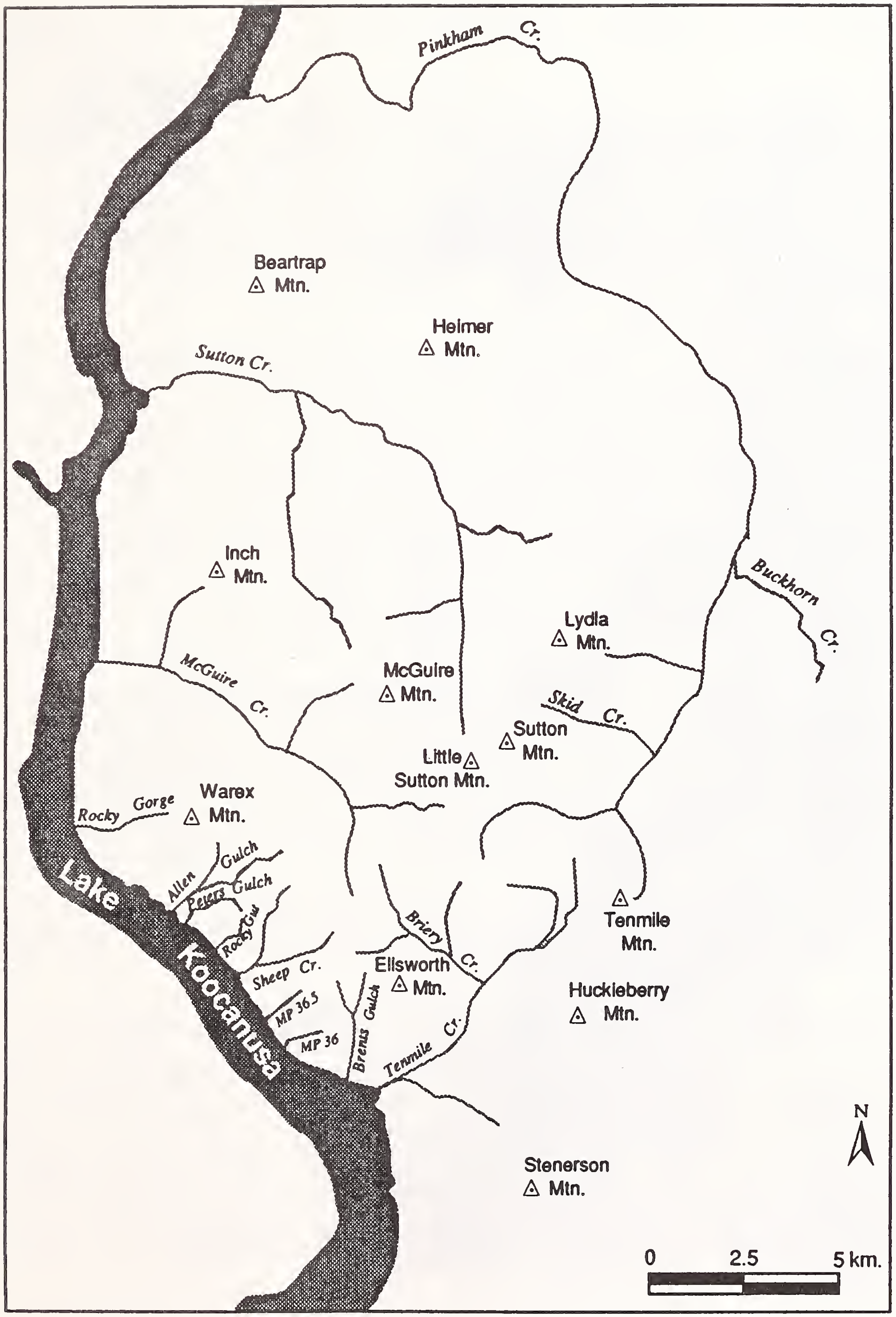

Figure 1. Map of the Ural-Tweed project area.

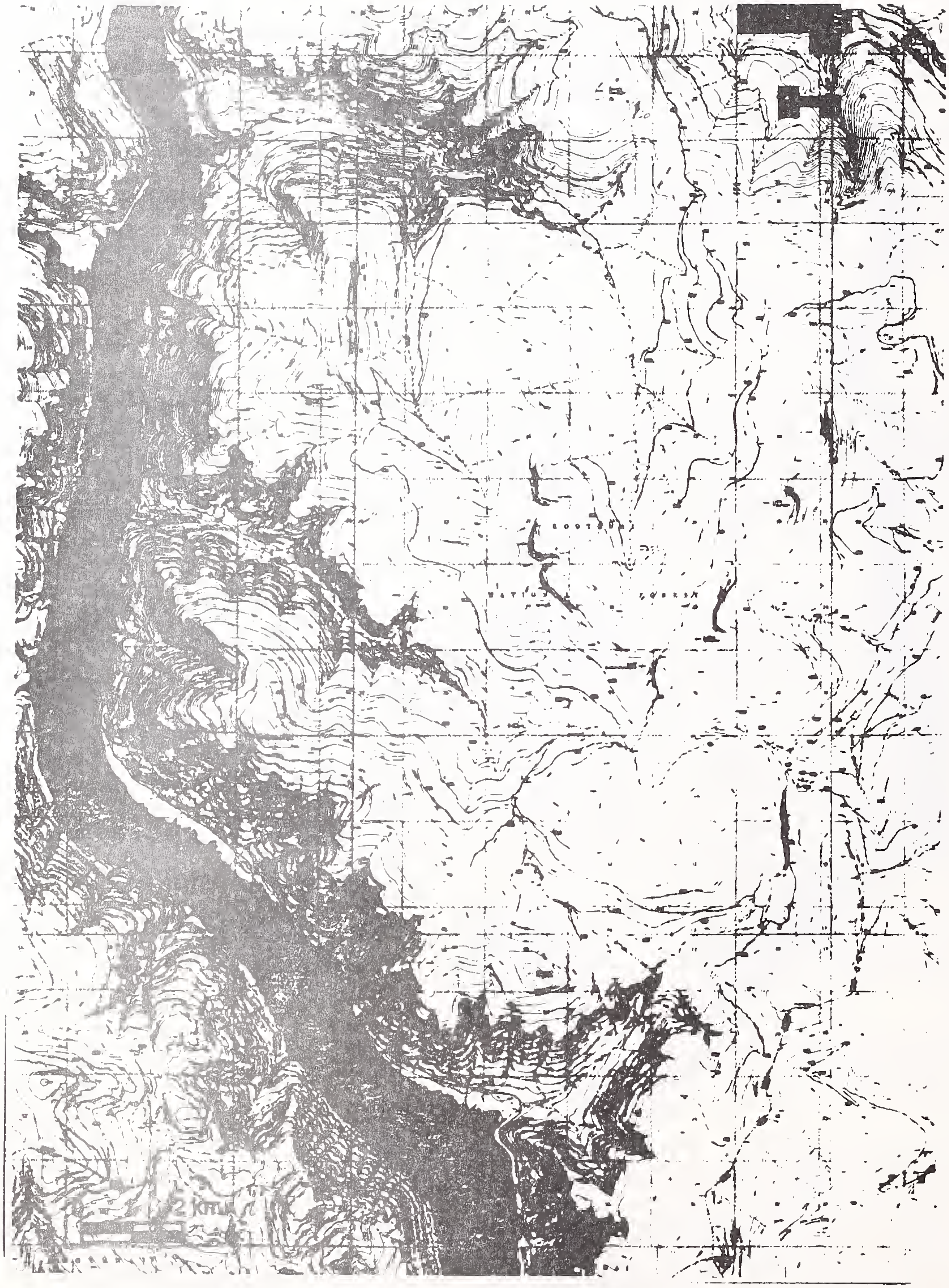

Figure 2. Contour map of north Salish mountains study area illustrating 2 topographic zones.

(*Calamagrostis rubescens*) are important grasses. Western yarrow (*Achillea millefolium*), silky lupine (*Lupinus sericeus*) and various asters (*Aster spp.*) are the most common forbs.

Douglas-fir type. This type occurs to an upper elevation of about 1,585 m throughout much of the project area. Douglas-fir is the major overstory species with some mixing of ponderosa pine and western larch (*Larix occidentalis*). Common snowberry and bearberry are the dominant shrubs. Pinegrass is the most predominant grass, with rough fescue also present. Western yarrow, heartleaf arnica (*Arnica cordifolia*) and woodrush pussytoes (*Antennaria luzuloides*) are common forbs throughout the area, while silky lupine occurs in areas with more open canopies.

Lodgepole pine type. This type had a lower elevational limit of approximately 1,585 m, and extended to the highest point on McGuire Mountain. Lodgepole pine (*Pinus contorta*) probably is a seral species with it's establishment influenced by large fires that occurred between 1910 and 1920. From 1940-1977, 69 small fires were recorded, mostly on the winter range segment (Brown 1979). Several small, spot fires have occurred on the area since the project was initiated. Lodgepole pine is the dominant overstory species, with sub-alpine fir (*Abies lasiocarpa*) occurring in understory of several of the stands. The most common shrubs were grouse whortleberry (*Vaccinium scoparium*), sitka alder (*Alnus sinuata*) and bearberry. Pinegrass was the most common grass, although elk sedge (*Carex geyeri*) is locally common. Common forbs are heartleaf arnica, mountain arnica (*Arnica latifolia*) and glacier lily (*Erythronium grandiflorium*). Silky lupine is also common in areas with open canopies.

Sub-alpine fir/Englemann spruce type. This type has a lower limit of 1,675 m on south-facing slopes and 1,340 m on north-facing slopes. Sub-alpine fir usually occurs with Englemann spruce (*Picea engelmannii*), but is sometimes found in pure stands. Common shrubs are menziesia (*Menziesia ferruginea*), sitka alder and grouse whortleberry. Beargrass (*Xerophyllum tenax*), both species of arnica, twinflower (*Linnaea borealis*) and queencup bead-lily (*Clintonia unifloria*) are common forbs. Common grasses are pinegrass and elk sedge.

In addition to the major types, small, isolated patches of western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*) occur throughout the project area. Further description of the project area can be found in Brown (1979).

Treatment units were located in habitats known to receive high seasonal use by bighorn sheep. We identified these areas using data gathered during the current project combined with Brown (1979). Cooperators in the project felt that well designed habitat manipulations would provide favorable vegetative responses - an increase in production of understory vegetation - which would in turn benefit the bighorn sheep and mule deer populations. Of the initial habitat improvement projects (Fig. 3) within the bighorn sheep range, five were located between Lake Koocanusa and Highway 37. The remaining 4 units were located above the highway; three on Stone Hill and one between McQuire and Tweed creeks. For additional discussion of the habitat treatment units see Young and Yde (1990).

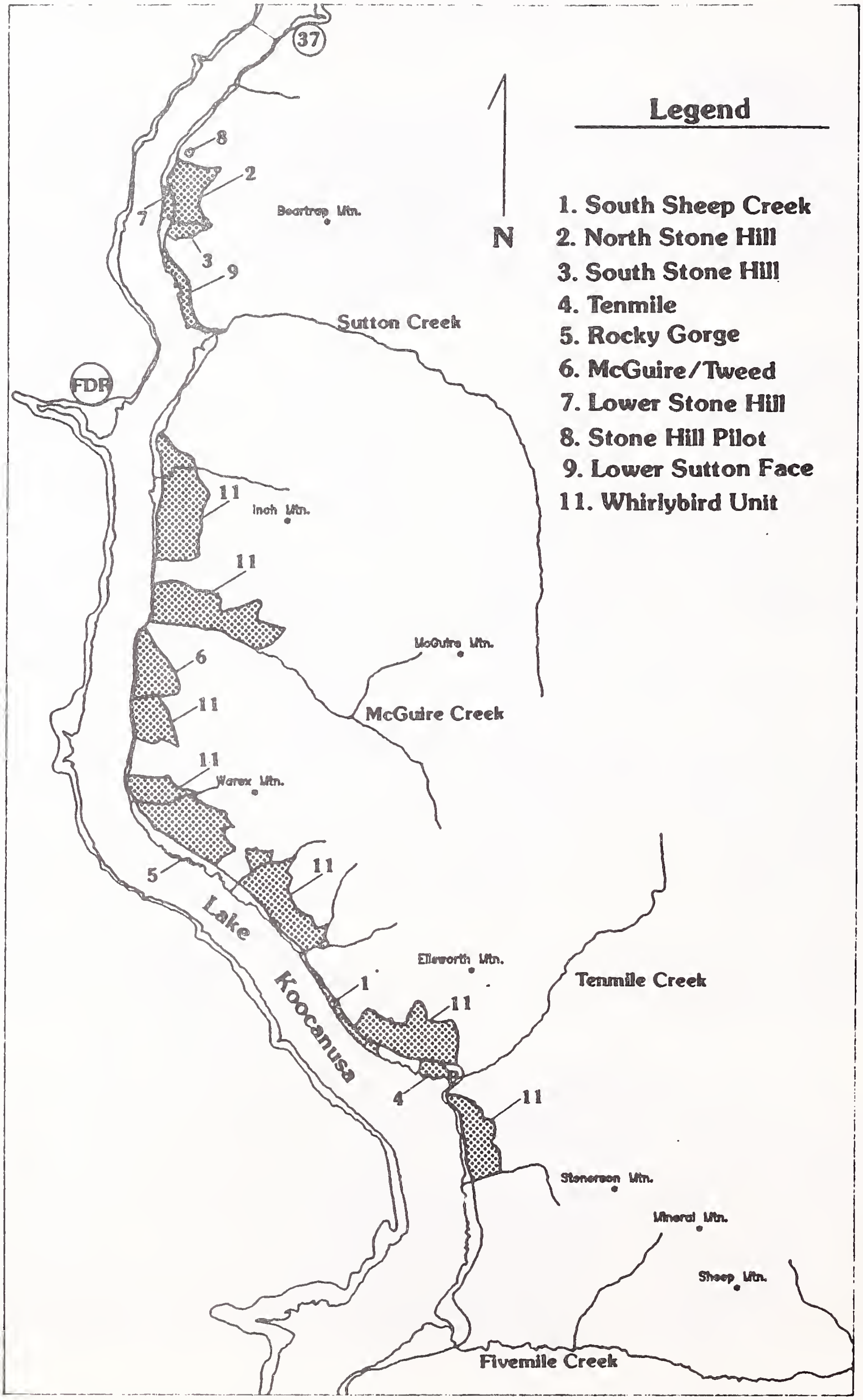

Figure 3. BPA funded habitat enhancements and Whirlybird logging units.

In addition to the habitat enhancements completed as part of the mitigation program, a large helicopter logging operation was conducted to enhance approximately 1,295 ha of winter range. Timber harvest units in this sale area were located in bighorn sheep and mule deer seasonal concentration areas. To avoid injury to or loss of the timber resource within the sale units, mitigation treatment units were located so treatments could be contained and not damage the sale units.

METHODS

Wildlife use of treatment areas

Objectives

1. Determine annual and seasonal distribution and analyze habitat use - vs - availability for bighorn sheep and mule deer.

2. Determine changes in distribution of the bighorn sheep and mule deer populations resulting from habitat treatments.

3. Determine size and age/sex composition of the bighorn sheep and mule deer populations.

4. Determine food habits, nutritional levels of the diet, and prevalence of lungworm for bighorn sheep.

Immobilization and trapping

We used two methods to capture bighorn sheep; (1) immobilization and (2) trapping. Trapping was the method used to capture mule deer.

Free-ranging bighorn sheep were immobilized using an intramuscular injection of xylazine hydrochloride (Rompun^R) and ketamine hydrochloride (Vetalar^R). The standard 3.0 cc dosage was 2.0 cc xylazine (100 mg/ml) and 1.0 cc ketamine (100 mg/ml) administered with hypodermic syringe darts propelled from a Palmer powder charged Cap-Chur gun. We were able to approach to within 15-30 m of sheep at mineral licks and grassy roadcuts adjacent to Highway 37.

A corral trap, set up around a mineral lick, was used to capture bighorn sheep and mule deer. This mineral lick received use throughout the year by mule deer and bighorn sheep. Sheep use of the trap site was greatest during periods when they concentrated in the area (ie. early winter and spring).

Since 1987, clover traps (Clover 1954) have been used to capture mule deer and bighorn sheep. Most traps were set at locations frequented by both mule deer and bighorn sheep. This provided the opportunity to capture either species. Due to topography and lack of access roads, much of the project area is inaccessible to trapping. Therefore, we located most of the traps in areas adjacent to Highway 37, but somewhat concealed from the public. Traps on Stone Hill and McGuire Creek were located along available access roads.

Marking

Depending on age, sex and body size, captured animals were fitted with radio transmitters, individually-marked vinyl neck bands, colored ear streamers or ear tags. In general, radio collars were placed on all bighorn sheep 1+ years of age. Female lambs (6-12 months old) were fitted with radio collars if their neck girth was ≥28 cm. Neck bands were placed on female lambs and adults not fitted with radio collars. Male lambs were fitted with colored ear-streamers because their necks were not large enough (<33 cm) to accommodate a radio transmitter or neck band without future adjustment. Combinations of streamer color were used to provide identification of individual animals.

Radio collars were placed on adult female mule deer and female fawns with neck girths of ≥28 cm. Fawns with <28 cm neck girth were marked with color coded neck bands. After the desired number of radio collars were deployed in a winter range segment, the remainder of the female mule deer were marked using neck bands. Captured males were fitted with expandable neck bands or ear tagged. Large or extremely aggressive males were released without handling if only one person was conducting the trapping. Radio collars and neck bands were individually color coded - solid color or a combination of collar color and colored symbols - for ease in identifying individual animals.

We gathered age and growth data from each of the animals that were handled. For bighorn sheep, we measured horn length (total and annuli), horn circumference (base and annuli), zoological length, neck circumference, heart girth and height at shoulder whenever possible. For mule deer, we measured zoological length, heart girth, neck girth, height at shoulder and diastemal length.

Animal movements and distribution

Systematic ground and aerial relocation surveys of the instrumented animals were conducted to determine seasonal distribution and habitat selection. Ground surveys were supplemented with aerial surveys through 1986. In 1987, we began using aerial surveys as the primary method to obtain animal relocations. Since 1987, we have used ground surveys and observations of animals obtained during daily field activities to supplement the data base. We used locations of instrumented animals to determine animal home ranges, seasonal distribution patterns and habitat selection.

Data recorded for each observation included Universal Transverse Mercator (UTM) coordinates, elevation, aspect, slope, habitat components and weather conditions. Group size, composition and activity were recorded for visual observations. Based on the judgement of the observer, all observations were placed into 1 of 5 categories.

- Category 1 - visual observations - included incidental observations and relocations where the animal(s) were observed.
- Category 2 - telemetry relocations where, in the judgement of the observer, the animal(s) was within a 100 m radius of the recorded UTM coordinates.

- Category 3 - similar to Category 2 except a 250 m radius was used to delineate potential error in the relocation.

- Category 4 - general telemetry relocation with an error radius of 500 m from the UTM coordinates.

- Category 5 - general telemetry relocation where only the drainage or sub-drainage could be determined.

Home range and habitat utilization analyses utilize only the Category 1 to 3 observations. For analysis, aerial and ground relocations were combined for each year and season. Relocations were analyzed using the TELDAY computer program (Lonner and Burkhalter 1983) to calculate home range sizes, average activity radii (AAR) and geographic activity centers (GAC). Analysis of variance (ANOVA) and two-sample t-tests (Lund 1989) were used to compare home range sizes and AAR between population-habitat units (PHU), movement patterns and years. Differences in mean distances travelled between seasonal ranges were also evaluated with a two-sample t-test.

Habitat analysis

Habitat types, based on Pfister et al. (1977), were not representative of existing vegetation on portions of the project area. Because of this, vegetation cover type (strata) maps developed by Big Sky Resource Analysts of Kalispell, under contract to the Forest Service, were used in habitat type analysis. These maps portrayed the vegetation in management compartments (strata) ranging from 1 - 120 ha in size. Given the possibility of some degree of error in locations, especially under timber canopies, we combined the strata into more generalized cover type maps based on the predominant overstory species. Six cover types were used in the analysis: NS=non-stocked, LPP=lodgepole pine, MC=mixed conifer, SAF=sub-alpine fir, PP=ponderosa pine, and NF=non-forested. Topographic attributes including slope, aspect and elevation were obtained from U.S.G.S. topographic maps.

Availability of cover types was determined by calculating the percent of each PHU occupied by each type. Availability of slope, aspect and elevation was determined using a random sampling technique (Marcum and Loftsgaarden 1980). Observed use of cover types, slope, aspect and elevation was the number of relocations in each type or category. Selection or avoidance of types or categories was analyzed using chi-square goodness-of-fit tests following Byers et al. (1984).

Population surveys

We conducted early and late, winter helicopter surveys (Bell 47 and Hughes 500D). Data gathered during these surveys was used to estimate size and composition of the two populations. Flights were conducted during late afternoon and evening when the animals were more active and the sun was behind the observer. We attempted to cover the entire sheep range during each of the surveys. During 1985, we attempted to survey the sheep during the spring while the ewes were more concentrated during lambing. This attempt was not productive due to lack of snow cover and topographic and vegetative conditions. Prior to the winter of 1987-88, we conducted helicopter surveys primarily for bighorn sheep. Mule deer observed during the surveys were recorded; however, much of the area occupied by mule deer was not systematically searched. Additionally, until the overstory canopy was opened by the Whirlybird logging operation, observability of mule deer was limited. Until the winter of 1990, the survey results for mule deer were minimal at best. During the February and December 1990 surveys, numbers of mule deer observed during the helicopter surveys increased.

Mark-recapture

We calculated standard population estimates (N) based on the results of the helicopter surveys (Rice and Harder 1977).

$$N = [(M + 1)(C + 1)/(R + 1)] - 1$$

M = Total marked animals within the population
C = Total animals observed during the survey
R = Number of marked animals observed during the survey

Big game hunter check station

The Koocanusa Bridge check station was operated during the general big game seasons from 1987 to date. During 1987 and 1988 project personnel operated the station for the first 15 days of the season and weekends thereafter. During 1989 and 1990, the station was open for the first 8 days of the general season, and weekends thereafter. The number of hunters and animals checked during the second week (days 9 - 13) of the season during 1987 and 1988 was minimal. During this period hunters and animals checked per day averaged 47.3 and 5.2, respectively. Based on these and the cost of operating the station, the station was not operated during this period in subsequent years.

In addition to the number of successful and non successful hunters, data collected included species, gender, age and diastemal length for the harvested animals. Antler characteristics - basal diameter, length and maximum inside spread of the main beams, and number of antler points - were measured for all males 1.0+ years of age. For mule deer, dressed weights, heart girth and thickness of subcutaneous fat at the xiphoid process (Austin 1984) were obtained.

Browse utilization

We established browse utilization transects to monitor annual shrub use in treatment and control areas (Anon. no date, Stickney 1966). We collected utilization data along the same general transects used to monitor the vegetation composition and structure. Browse utilization data were collected during April and May prior to the growing season. Originally, we planned to collect browse utilization data during all seasons of the year. However, time constraints and other project commitments precluded data collection for any season other than spring.

Pellet group surveys

Pellet group transects - again corresponding to the general vegetation monitoring transect - were established in each of the treatments/controls. Pellet group transects were completed in early spring in conjunction with browse utilization data collection. They were repeated again in the summer in conjunction with the vegetation diversity and production data collection. At every tenth point along the respective transect, a circular plot (13.5 m^2) was searched for pellet groups. Every pellet group within the plot was recorded and identified to genus whenever possible. We did not try to differentiate between bighorn sheep and deer feces. Pellet groups were placed in one of five categories: bighorn sheep/deer, elk, moose (*Alces*), elk/moose and cattle (*Bos*). A total of 20 plots per treatment/control per season of collection were completed. It was assumed that pellets decomposed in less than 12 months, therefore, during the annual pellet group surveys we were only counting groups which had been deposited during the preceding 12 months.

Fecal Analysis - Food habits, nutrition and lungworm

Fecal samples were collected monthly from May 1985 through 1988. Since 1988 pellet group collections have been opportunistic and were not made on a monthly basis. Only defecations known to be from bighorn sheep were collected. Sex and age of the individual bighorn sheep was noted.

Each sample was divided into two subsamples - one was analyzed for the presence of lungworm (*Protostrongylus spp.*) larvae, the other was analyzed to determine the level of 2.6 diaminopimetic acid (DAPA) and fecal nitrogen. Additionally, a monthly composite sample of 5 pellets from each group was made and used for microhistological determination of food habits (Todd and Hansen 1973, Dearden et al. 1975). Lungworm analysis (Thorne 1982) was conducted by the Montana State Veterinary Research Laboratory, Bozeman, Montana. DAPA and fecal nitrogen analysis to determine nutritional quality of the bighorn sheep diets (Nelson et al. 1982) and food habits analysis were done by the Wildlife Habitat Management Laboratory, Washington State University.

Vegetation monitoring

Objectives

1. Determine initial changes in plant composition, herbaceous production, shrub frequency and volume, and overstory canopy resulting from habitat enhancements;

2. Determine long-term vegetative responses to habitat treatments, including duration of beneficial results and potential retreatment schedule; and,

3. Determine which habitat treatments produced the desired results. Compare results to determine which treatments should be maintained in the future.

Monitoring transects

We established vegetation monitoring transects in selected treatment and paired control areas. Treatment and paired control areas were in close proximity and had similar habitat and topographic elements. Vegetation data collection was completed within as short of period of time as possible. This reduced the variability between the data.

Where possible, transects crossed to form an X in the treatment/control area. Transect segments extended diagonally from one corner of the treatment/control area across the unit to the opposite corner. Because treatment and control areas were of different sizes and shapes, lengths of the segments/transects varied. End points of the transect segments were located to maximize the area of coverage, but at least 15 m from the corner of the treatment/control area. This design allowed for monitoring the vegetation across the entire treatment/control area, including variation due to changes in elevation and topography, while eliminating the effect of treatment edge. We developed this sampling technique using a combination of methods described by several authors (Anonymous 1977, Chambers and Brown 1983, Floyd and Anderson 1984, Nudds 1977, U.S. Dep. Inter. 1978) and consultations with personnel from Montana State University, University of Montana, and the U.S. Forest Service. Plant nomenclature follows Hitchcock and Cronquist (1973).

We made several modifications to conform sampling methods to a given situation. Modifications due to topography, vegetation and/or configuration of the treatment/control area were made. Where changes in methods were needed, the same modifications were made in both the treatment and paired control area. The Rocky Gorge Peninsulas were small areas adjacent to Lake Koocanusa. In these units, transects were located parallel to the off shore side of the unit. They were approximately mid-distance between the high water mark and the off shore side of the unit. Within the North Stone Hill Unit the series of rough, rocky benches precluded completing the transects in an X across the unit. Instead, a series of transects were completed along selected benches located within three elevational zones.

Sampling was conducted between the second week in June and mid-August. During this period, grasses had matured to at least the boot stage and the majority of forbs were flowering. As the sampling period progressed, the grasses would mature to seed ripe and then cure. Forbs would develop, flower and mature to seed ripe and begin to desiccate by the end of the sampling period. Our data collection goals were to conduct vegetation surveys 2 years prior to treatment and for 2 years following treatment. We felt that the 2 years of pre-treatment data would provide a suitable data base for future comparisons. We also felt that collection of data for 2 years following treatment would document the initial plant response to the treatment. Because of the lack of vegetation after burning, treatment areas were not monitored the year of treatment. Through consultation with the various cooperators involved in the project, we decided to obtain 2 years baseline data from the control areas. After that, data was gathered in the control areas only if data collection occurred in the paired treatment area. In some treatment areas there was at least a 2 year lag period between slashing and the follow-up prescribed burn. This created a corresponding gap in the data available for analysis.

Ground cover, plant composition and understory canopy composition in the treatment and control areas were estimated from 100 sampling points located approximately equidistant along the transect segments - 200 points/transect (Chambers and Brown 1983, Floyd and Anderson 1984, Hays et al. 1981, Nudds 1977, and U.S. Dep. Inter. 1978). To determine the distance between sampling points, the length of the transect segment was estimated and then divided by 100 (the number of sampling points/segment). The investigator would walk along the transect and stop at the pre-determined distance between points. The sampling point was a point directly in front of the toe of the investigators boot/shoe. At each point, ground cover (vegetative, litter, soil, rock, etc.) was recorded, as well as, the understory canopy components in each layer to a height of 1.0 m above the sampling point.

At every tenth point along each segment the following were completed using the point as the center of the plot unless otherwise noted: (Note: Due to topographic and vegetative features of both the North Stone Hill and McGuire/Tweed treatment areas, fixed plots were selected throughout the units in a systematic manner and monitored on an annual basis using the standard sampling techniques.)

1. We used a 0.22 m^2 (61 cm X 36.5 cm) frame to estimate grass and forb production (U.S. Dep. Inter. 1978). Beginning with the 1988 sampling season, a 0.27 m^2 (61 cm X 44.5 cm) frame was used; an error when constructing the new frames resulted in a different size. The rear, left-hand corner of the plot frame was placed over the sampling point and vegetative production (grams/species) was ocularly estimated. In addition, at 4 of the 20 plots, randomly selected prior to starting, the production (by species) was estimated and then the plots were clipped with the individual species weighed. A correction factor was then calculated to convert the estimated weights to actual weights (estimated weight ÷ actual weight). Because of the number of samples and logistics of sorting and drying the number of clipped samples, the green weights were used with no conversion to dry weights. Green weights (grams/0.22 m^2 for 1985-87, grams/0.27 m^2 for 1988 to date) were converted to kg/ha. General phenology of the vegetation in the area of the transect was recorded.

2. A shrub characterization/volume plot was centered on the sampling point. Plot size varied according to species. A 13.5 m^2 plot (2.1 m radius) was used for high frequency species within a plot: rose, shiny-leaf spirea (*Spiraea betulifolia*), common snowberry, huckleberry (*Vaccinium spp.*), raspberry (*Rubus spp.*) and any species with similar growth form. A 40.5 m^2 plot (3.6 m radius) was used for serviceberry, redstem ceonothus (*Ceonothus sanquineus*), shiny-leaf ceonothus (*C. velutinus*), oceanspray (*Holodiscus discolor*), ninebark (*Physocarpus malvaceus*), antelope bitterbrush (*Purshia tridentata*) and other shrub species which were generally larger and less numerous within a plot. The first 10 plants of each species, encountered along a clockwise arc beginning at a random point, were characterized by age and form class. Height (up to 2.0 m), length (the longest portion of the plant) and width (perpendicular to the length) were used to estimate shrub volume - an indicator of production. Heights >2.0 m would have to be estimated, therefore, they were not

measured. We also considered leader growth above 2.0 m to be out of reach of browsing animals.

Cylindrical shrub volumes were calculated using the following (Lyon 1984):

$$\text{Volume} = \pi h l w/4$$

$\pi = 3.14$ l = length
h = height w = width

We also calculated plant frequency for each of shrub species (number of plants/ha). Average shrub volume and frequency were used to calculate total volume (m^3/ha) for each shrub species.

3. We used a variable plot - basal area factor (BAF) of 20 - (Dilworth and Bell 1982, U.S. Dep. Agric. 1985) to estimate tree basal area for mature - >38 cm diameter breast height (DBH) - and large regeneration/second growth - 13-38 cm DBH. The number of stems/acre of small regeneration - <13 cm DBH - was estimated using a 13.5 m^2 fixed plot.

4. We used 4 spherical densiometer readings to monitor changes in forest canopy (Strickler 1959). Four readings were made at 90° intervals around the sample point. During 1985, densiometer readings were made at 90° intervals at a distance of 1.0 m from the plot center. After review of Strickler (1959), we determined this methodology was double sampling a portion of the overstory canopy. Therefore, the procedure was modified and densiometer readings have since been obtained at a distance 5-7 m away from plot center. Starting in 1988, another modification was made to the sampling method. Two densiometer readings were made at each reading point, one recording the total canopy coverage (living and dead material) and one recording the canopy coverage resulting from only living material. Comparison of these 2 canopy coverage readings provides a determination of the percent of the canopy killed by the prescribed burn. It will also allow us to determine how long the dead trees remain standing.

5. Vegetation composition and production vary with changes in topographic position and exposure. Slope (degrees) and aspect (degrees from north) at the sample point were determined using a clinometer and compass, respectively.

Photo plots

In order to provide a long-term visual record of changes in vegetation structure, 3 to 5 photo plots (Jones, 1968) were established in each treatment/control area. Plots were permanently marked using metal posts. A 0.5 m x 2.0 m board, divided into 0.1 m squares, alternately painted black and white, was placed at one end of the plot and a photo taken with a 35 mm camera (50 mm lens, 64 ASA Kodachrome film) from 1.0 m above the opposite end of the plot. To provide uniformity between photos, the camera was focused on a spot 0.5 m above the bottom of the photo board. We experimented with the photo board held at various distances and reviewed analyses presented by Hays et al. (1981). We determined 15 m was the optimal distance between the ends of the photo plot. This distance allowed monitoring of several vegetative layers.

Photos qualitatively measure visual obstruction present and demonstrate changes in vegetative structure over time. To obtain a quantitative measure of the vegetative cover, we modified methodologies described by Nudds (1977) and Hays et al. (1981). Slides of the photo plots were projected onto a grid dividing each of the black and white squares into quarters. This provided a total of 400 blocks which were used to determine percent of the cover board obscured by vegetation. The number of squares totally or partially obscured by vegetation were recorded. The percent cover was then calculated (number of squares with vegetation ÷ 400). Changes in percent cover for a plot, or a series of plots, over time will provide another tool for assessing the shrub response (growth and relative density), as well as the establishment of conifers into treatment areas.

RESULTS and DISCUSSION

Trapping was conducted during January and February 1990 (18 days). The effort was directed primarily at capturing additional bighorn sheep and fitting them with radio collars. One adult female bighorn sheep and 3 female mule deer were captured, marked and released. Several bighorn sheep fed on the bait at the Rocky Gut trap sites, however, only one sheep was captured. Weather conditions and snow accumulations during the winter did not concentrate the animals on the lower slopes. Results of earlier trapping efforts are summarized in Yde et al. (1986) and Yde and Coates (1990).

Marked animals

To date, 31 bighorn sheep have been marked for individual identification (Table 1, Fig. 4). Of the 31 sheep which have been marked since January 1978, 18 are alive and have recognizable collars. Four ear-streamered males have sufficient horn growth to obscure the streamers. Therefore, they are not included in the sample of marked animals.

A summary of the mule deer marked during the course of the project is presented in Table 2.

Population estimates

Standard mark-recapture population estimates (Rice and Harder 1977) were calculated from data gathered during total coverage helicopter surveys (Table 3). These results illustrate a wide variation in total number of animals, as well as, number of marked individuals observed during the surveys. Terrain and habitat types, combined with behavior patterns of the animals make the project area difficult to survey.

Table 1. Bighorn sheep marked in the Ural-Tweed project area, 1984 to present.

Animal Number	Date of Capture	Trap Site	Sex	Age at Capture	Mark Type	Color	Pattern
1	841211	MP36.5	F	5	Radio	White	Solid
	880127	MP36		9	Radio	Lbl/Wht	Hearts
2[1]	841212	MP36.5	M	2	Radio:D	Wht/Blk	Alternate
3	841213	PetGlc	M	1	Radio:NF[2]	White	Solid
4[3]	841217	MP38.5	M	5	Radio:D	Red	Solid
5	850116	TweedCr	F	2	Radio:NF	Wht/Blk	Center Line
6	850615	RGT	F	5	Radio:NF	Blue	Solid
7	850616	RGT	F	5	Radio:NF	R/W/B	Alternate
8[4]	850616	RGT	F	1	Neckband	Red/Wht	Center Line
9	850616	RGT	M	0	Earstream	L:Blu,R:Blu	
10[1]	780111	PckGlc	F	3	Radio:D	White	Solid
11	780117	SutCr	M	3	Radio:NF	Blue	Solid
12	851219	SheepCr	M	7	Radio:NF	Yellow	Solid
13[4]	860718	RGT	F	7	Radio:D	Green	Solid
14[1]	861214	RGT	M	1	Radio:D	Yel/Blk	Alternate
15	870123	StHill	F	1	Radio:NF	Yellow	Solid
16[3]	870123	StHill	M	6	Radio:D	Wht/Blk	Center Line
17	870131	StHill	M	0	Earstream	L:Yel,R:Blu	
18	870217	MP36.5	F	5	Radio:NF	Red	Solid
19	870217	RGT	M	0	Earstream	L:Blu,R:Red	
20	870218	RGT	F	0	Radio:NF	Wht/Blk	Alternate
21	870218	RGT	F	0	Eartags	Red	Numbered
22	870301	StHill	M	0	Earstream	L:Red,R:Wht	
23	870301	RGT	F	2	Radio:NF	Wht/Blk	X's
24	870311	StHill	M	2	Radio:NF	Green	Solid
25	871214	MP36.5	F	0	Radio	Wht/Blk	Diamonds
26	871217	RGT	M	0	Earstream	L:Wht,R:Wht	
27	880121	MP36.5	F	3	Radio	Yel/Blk	Arrows
28	880122	RGT	F	3	Neckband	Wht/Blk	Dots
29	890107	RG5	F	0	Neckband	Red/Wht	Slashes
30[5]	88-spring	?	F	?	Neckband	Lbl/Wht	Triangles
31	890107	RGT	F	5	Radio	Wht/Blk	Checkerboard

[1] Animal killed by vehicle on Highway 37.
[2] Radio collar is no longer functioning.
[3] Animal harvested by hunter during 1990 season.
[4] Mortality of unknown cause, may have been poached.
[5] Additional information not available, field forms lost.

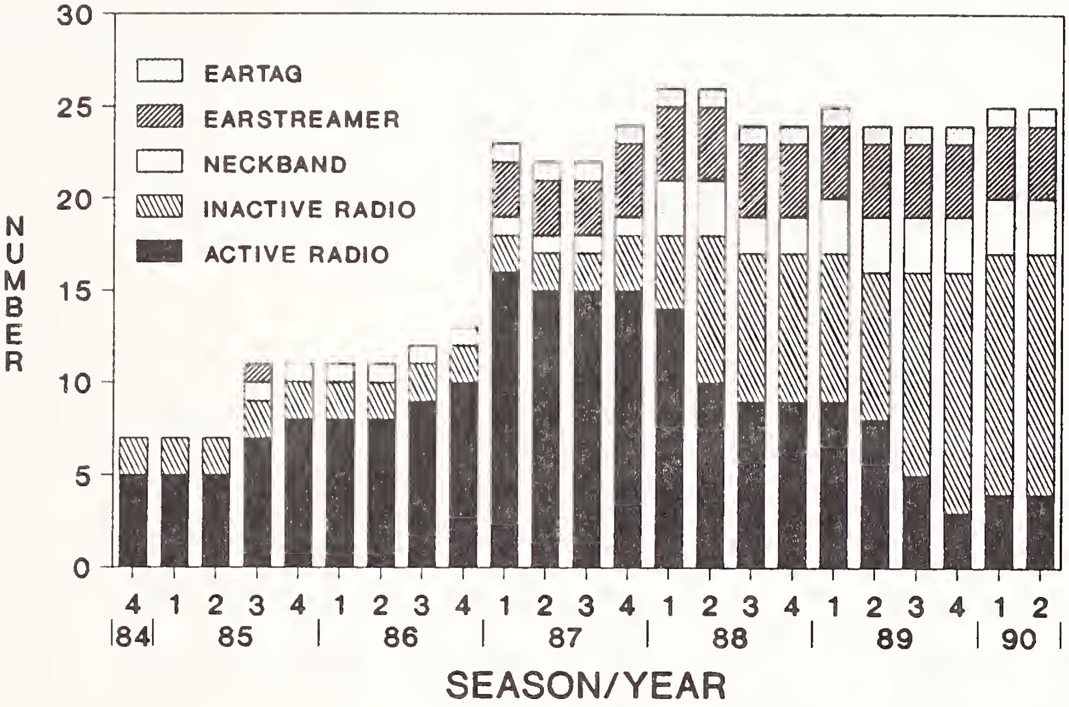

Figure 4. Number of marked bighorn sheep, by marker type, 1984 to present. Seasons are represented by numbers: spring (1), summer (2), fall (3), and winter (4).

Bighorn sheep

We developed population trends for the Ural-Tweed bighorn sheep population (Fig. 5 and Fig. 6). Figure 5 illustrates the population trend since the project was initiated in 1984. During 6 years of data collection, the population has increased from approximately 65 sheep to approximately 185 animals in the population. The confidence interval (90%) associated with each estimate is also shown. In most cases, these intervals were very wide. The number of sheep observed during each survey increased as the population increased. At the same time, we observed a lower percentage of the marked animals. These two factors resulted in broader confidence intervals around the population estimates during the later years of the study.

We combined classification data from all visual observation during each year to determine demographic characteristics of the population. Age and sex composition of the population has varied during the project (Fig. 7). Adult females accounted for at least 40% of the population each year. The number of lambs per 100 ewes has consistently been 40:100 or better each year (Fig. 8).

Observed recruitment rates (yearlings:100 non-lamb females) decreased the period (Fig. 9). This is probably due largely to a decrease in the number of visual observations of sheep. This has been due to changes in the primary duties

Table 2. Mule deer marked in the Ural-Tweed project area, 1984 to present.

Animal Number	Date of Capture	Trap Site	Sex	Age at Capture	Mark Type	Status	Frequency	Color	Pattern
1	850500	RGT	M	3	NB[1]	Unkn.[2]		Orange	Solid
2	870117	SC2	F	4	R[3]	Active	1390	White	Solid
3	870122	SC2	F	5	R	Dead 870312		Wht/Blk	Alternate
4	870124	SC2	M	0	NB	Unkn.		Org/Blk	Hr-glass/Square
5	870204	RGT2	F	1	R	Dead 8710??		Wht/Blk	Doughnuts
6	870204	MP36.5-2	F	3	NB	Unkn.		Grn/Yel	Dashes
7	870211	MP36.5-2	F	0	NB	Unkn.		Yel/Blk	Bars
8	870227 881216	RG1 AG1	F	1 2	NB R	 Active	 1950	Grn/Wht Blu/Wht	4's Stars
9	870227	SH1	F	1	NB	Unkn.		Blk/Wht	X's
10	870307	RGT1	M	0	NB	Unkn.		Yellow	Solid
11	870308	SH2	F	0	NB	Unkn.		Red/Wht	Pluses
12	870308 880124	SH2 SH2	F	3 4	NB R	 Active	 1660	White Red/Wht	Solid Pluses
13	870312	RGT2	M	1	NB	Unkn.		Yel/Blk	Solid Dots
14	870424	RGT2	F	1	R	Dead 881105		Wht/Blk	Solid Stars
15	870427 890422	MP35.8 BG1	F	2 4	R R	 Active	 1920	Wht/Blk Red/Wht	Pluses Checkerboard
16	870428	MP36	F	2	R	Inter.[4]	1370	Wht/Blk	Alternate
17	870501	MP36	F	3	R	Inter.	1580	Yellow	Solid
18	870509	MP36	F	4	R	Inter.	0860	Org/Blk	Alternate
19	871210 891201	MP35.8 MP36.5-1	F	0 2	R R	 Active	1080 1810	Yel/Blk Yel/Blk	Alternate H's
20	871210	SH1	F	3	R	Dead 901103		Red/Grn	Alternate
21	871211	MP36.5-2	F	5	R	Active	1450	Blk/Wht	Diamonds
22	871212 880123	RGT2 RGT2	F	0 0	R R	Dead 901023		Wht/Blk Wht/Blk	Sawtooths Centerline
23	871214	RGT1	F	6	R	Dead 88/89		Wht/Blk	Wavy Line
24	871216	RG5	F	3	R	Dead 88/89		Blu/Wht	Dashes
25	871216	SH1	F	4	R	Active	1530	Red/Wht	Dashes
26	871218	SH1	M	0	NB	Unkn.		Red/Wht	Solid Dots
27	871218	SH2	F	88[5]	R	Active	1480	Red	Solid
28	871218	RGT2	F	0	NB	Unkn.		Wht/Red	Solid Triangles
29	880120	SC1	F	5	R	Active	1620	Wht/Blk	Dashes

Table 2 (continued). Mule deer marked in the Ural-Tweed project area, 1984 to present.

Animal Number	Date of Capture	Trap Site	Sex	Age at Capture	Mark Type	Status	Frequency	Color	Pattern
29	880120	SC1	F	5	R	Active	1620	Wht/Blk	Dashes
30	880121	SC1	F	0	R	Active	1570	Wht/Blk	Solid Dots
31	880122	MP36.5-2	F	4	R	Active	1430	Yel/Blk	Open Triangles
32	880122	SC1	F	0	R	Active	1720	Wht/Blk	Arrows
33	880122	RG5	F	0	R	Missing[6]	1510	Blu/Wht	Chevrons
34	880124	MP36	F	3	R	Active	1700	Yel/Blk	Arrows
35	880124	RGT2	F	4	R	Inter.	1460	Wht/blk	Solid Triangles
36	880124	RG2	F	8	R	Active	1670	Blu/Wht	Solid Squares
37	880124	SH1	F	8	R	Active	1650	Red/Wht	Zig-Zag Line
38	880125	MP36	F	0	NB	Unkn.		Yel/Blk	Solid Squares
39	880125	SC1	M	0	NB	Unkn.		Wht/Blk	Gates
40	880125	RGT2	M	0	NB	Unkn.		Wht/Blk	Solid Squares
41	880225	SH1	F	5	R	Active	1910	Red/Wht	Solid Stars
42	880225	SH2	F	0	R	Active	1900	Red/Wht	Solid Hearts
43	881204	RG1	F	4	R	Active	1890	Blu/Wht	Open Rectangles
44	881205	AG3	M	1	Tags[7]	Unkn.		Red	
45	881207	AG3	F	0	R	Dead 901021		Blu/Wht	Bars & Solid Circles
46	881208	RG5	F	5	R	Active	1840	Blu/Wht	Aternating
47	881208	AG3	M	3	Tags	Dead Fall 90		Red	
48	881215	AG2	F	6	R	Active	1850	Blu/Wht	Solid Dagger
49	881215	RG1	F	7	R	Active	1870	Blu/Wht	Solid Circles
50	881215	RG5	F	2	R	Active	1880	Blu/Wht	Bars
51	881216	RG5	M	1	Tags	Unkn.		Red	
52	881216	RG1	F	4	R	Active	1210	Blu/Wht	Hearts
53	890106	AG1	F	5	NB	Unkn.		Blu/Wht	Alter. Dots
54	890107	RG6	F	8	NB	Unkn.		Blu/Wht	Wavy Line
55	890107	AG3	F	6	NB	Unkn.		Blu.Wht	Pluses
56	890107	AG2	M	0	Tags	Unkn.		Red	
57	890108	MC3	F	7	R	Active	1970	Grn/Wht	Solid Squares
58	890108	MC1	F	3	R	Active	1980	Grn/Wht	Chevrons
59	890108	RG5	F	1	NB	Unkn.		Blu/Wht	Alternating Bars and Dashes
60	890109	MP36	F	0	Tags	Unkn.		Red	
61	890109	AG1	F	0	Tags	Unkn.		Red	

Table 2 (continued). Mule deer marked in the Ural-Tweed project area, 1984 to present.

Animal Number	Date of Capture	Trap Site	Sex	Age at Capture	Mark Type	Status	Frequency	Color	Pattern
62	890109	AG2	F	3	NB	Unkn.		Blu/Wht	Doughnuts
63	890109	RG3	M	1	Tags	Unkn.		Red	
64	890109	RG6	F	4	NB	Unkn.		Blu/Wht	Center Stripe
65	890109	RG6	M	0	Tags	Unkn.		Red	
66	890109	RG5	F	0	NB	Unkn.		Blu/Wht	Open Triangles
67	890109	MC3	M	0	Tags	Unkn.		Red	
68	890109	MC2	M	0	Tags	Unkn.		Red	
69	890110	RGT2	F	0	NB	Unkn.		Wht/Blk	Chevrons
70	890110	BG1	F	0	NB	Unkn.		Yel/Blk	2's
71	890110	MC3	F	0	R	Active	0930	Grn/Wht	Bars
72	890110	MC1	F	0	Tags	Unkn.		Red	
73	890110	MC2	M	2	Tags	Unkn.		Red	
74	890111	MP36.5-1	M	1	Tags	Unkn.		Red	
75	890111	RGT2	F	5	R	Active	1790	Wht/Blk	Solid Daggers
76	890111	MP36	M	0	Tags	Unkn.		Red	
77	890111	BG1	F	2	R	Active	1800	Yel/Blk	Pluses
78	890111	MC1	F	1	R	Dead Spr. 89		Grn/Wht	Solid Circles
79	890111	MC3	F	0	R	Active	0920	Grn/Wht	2's
80	890111	MC2	F	8	Tags	Unkn.		Red	
81	890112	RGT2	F	0	R	Active	1220	Wht/Blk	Cresent Moons
82	890112	RGT1	M	0	Tags	Unkn.		Red	
83	890112	SC1	M	0	Tags	Unkn.		Red	
84	890112	MP36	F	6	NB	Unkn.		Yel/Blk	Chevrons
85	890112	RG4	F	1	R	Active	1240	Blu/Wht	Solid Triangles
86	890112	MC1	M	0	Tags	Unkn.		Red	
87	890113	RGT1	F	6	R	Active	0690	Wht/Blk	Bars & Circles
88	890113	RGT2	M	0	Tags	Unkn.		Red	
89	890113	SC1	F	0	Tags	Unkn.		Red	
90	890113	BG1	F	1	NB	Unkn.		Yel/Blk	Doughnuts
91	890113	MC1	F	2	R	Active	0780	Grn/Wht	Center Stripe
92	890113	MC3	F	1	R	Active	1265	Grn/Wht	Dashes
93	890421	MP36.5-1	F	1	R	Active	1930	Red/Wht	Solid Triangles
94	890421	RGT2	F	0	R	Active	1940	Red/Wht	Solid Daggers
95	890421	BG1	M	1	Tags	Unkn.		Red	

Table 2 (continued). Mule deer marked in the Ural-Tweed project area, 1984 to present.

Animal Number	Date of Capture	Trap Site	Sex	Age at Capture	Mark Type	Status	Frequency	Color	Pattern
96	890422	MP36.5-1	F	7	R	Active	1180	Grn/Wht	Cresent Moons
97	890422	RG2	M	0	Tags	Unkn.		Red	
98	890423	AG1	M	0	Tags	Unkn.		Red	
99	890423	RG6	F	4	R	Active	1060	Grn/Wht	Pluses
100	890423	BG1	F	4	R	Active	0800	Grn/Wht	Solid Triangles
101	890424	RGT1	F	0	R	Inter.	0910	Wht/Blk	Solid Squares
102	890424	MP36	F	2	R	Active	1755	Yel/Blk	Dashes
103	890424	BG1	F	3	R	Active	1100	Red/Wht	Center Line
104	890424	RG2	F	0	R	Active	0710	Wht/Blk	Y's
105	890425	RG6	F	3	R	Inter.	0830	Wht/Blk	X's
106	890425	RG5	F	6	NB	Unkn.		Blu/Wht	Slashes
107	900221	RGT	M	0	Tags	Unkn.		Red	
108	900221	RGT	M	0	Tags	Unkn.		Red	
109	880227	TM1	M	0	Tags	Unkn.		Red	
110	880228	TM1	M	0	Tags	Unkn.		Red	

[1] NB = Neckband

[2] Unkn. = Status of the collar and/or animal is unknown.

[3] R = Radio collar

[4] Inter. = The radio collar works on an intermittent basis and the animal is not located during all relocation surveys.

[5] 88 = Age of the animal is unknown.

[6] Missing = We suspect the animal was harvested during the 1988 hunting season and the radio lcollar not returned.

[7] Tags = The animal was marked with numbered ear tags only.

Table 3. Summary of helicopter surveys conducted in the Ural-Tweed bighorn sheep range, 1985-1990, with a population estimate based on the results of each survey.

		No. Animals Observed								
Date	Hours Flown	Y	F	M	Un	Total (C)	Total Marked (M)	Marked Animals Observed (R)	Observability (R/M)	Population Estimate (N)
Bighorn Sheep										
03/13/85	3.0	2	4	0	0	6	7	0	0	0[1]
04/09/85	4.0	4	6	14	0	24	7	2	0.29	66
05/23/85	5.0	1	2	0	0	3	7	0	0	0[1]
12/04/85	4.5	9	14	8	0	31	10	3	0.30	87
03/01/86	3.0	3	10	8	0	21	11	4	0.36	52
03/02/86	3.0	1	12	14	0	27	11	9	0.81	33
12/09/86	5.5	10	17	19	1	47	12	5	0.42	103
12/19/87	5.5	7	18	16	0	41	24	13	0.54	74
02/23/89	7.9	14	17	20	0	51	25	10	0.40	122
02/15/90	9.5	17	29	12	0	58	24	5	0.21	245
12/20/90	6.6	16	34	18	0	68	18	6	0.33	186
Mule Deer										
02/20/90	9.5					295	73	17	0.23	1140
12/20/90	6.6	115	238	53	9	415	70	21	0.29	1322

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[1] Due to poor survey results, no population estimate was calculated.

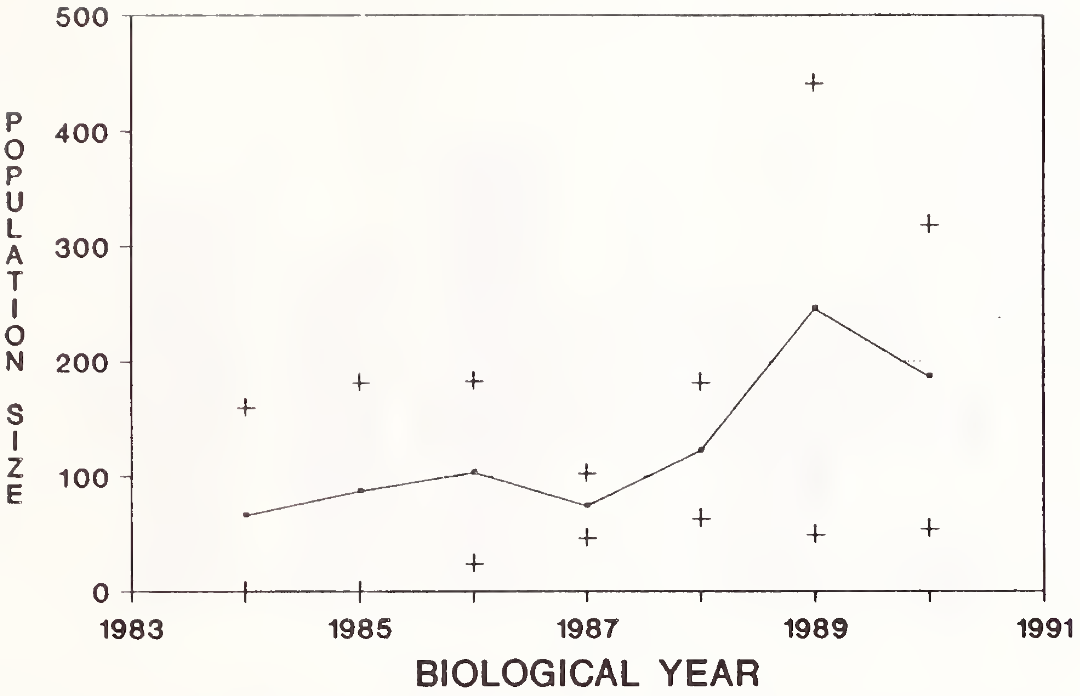


Figure 5. Bighorn sheep population trend, Biological Year 1984 to 1990, based on annual population estimates. Confidence intervals (90%) are indicated by +.

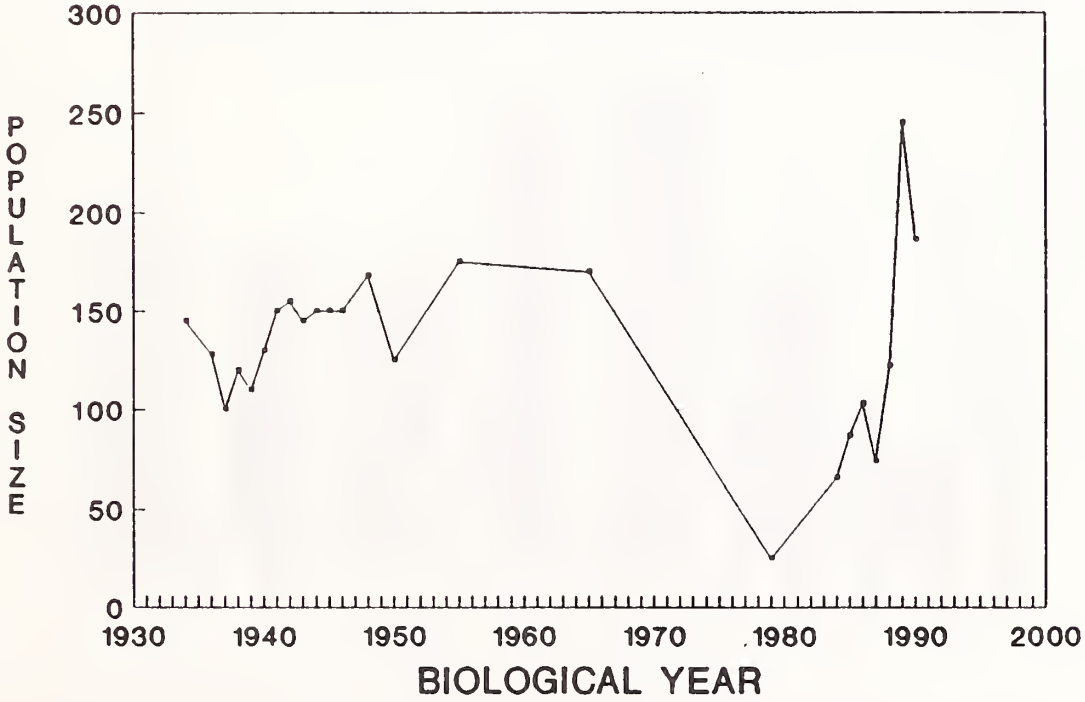


Figure 6. Bighorn sheep population trend, Biological Year 1934 to 1990.

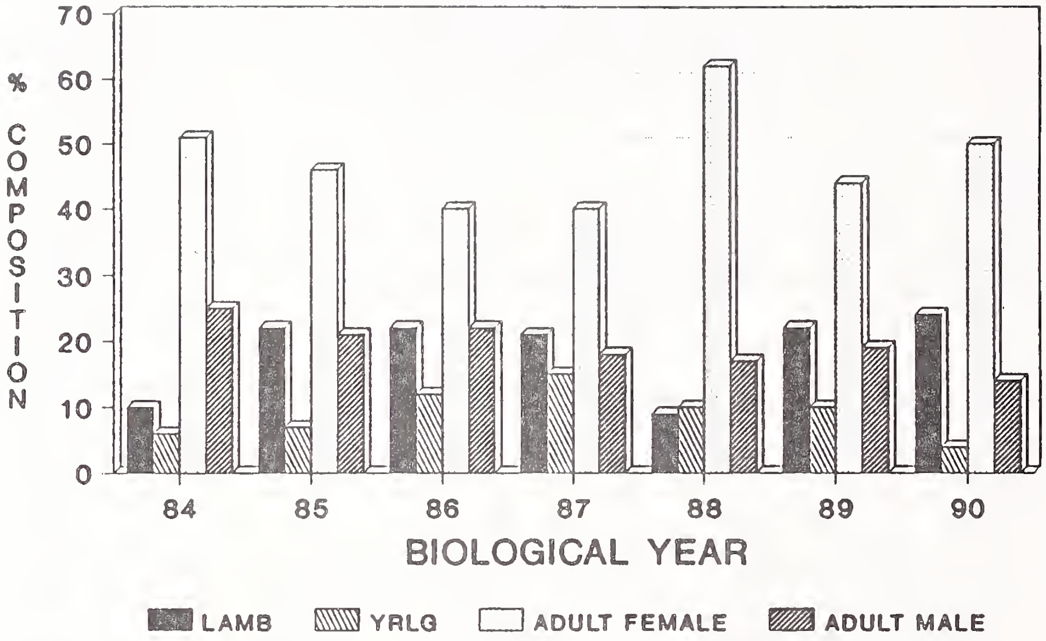


Figure 7. Sex and age composition of the Ural-Tweed bighorn sheep population, 1984 to 1990.

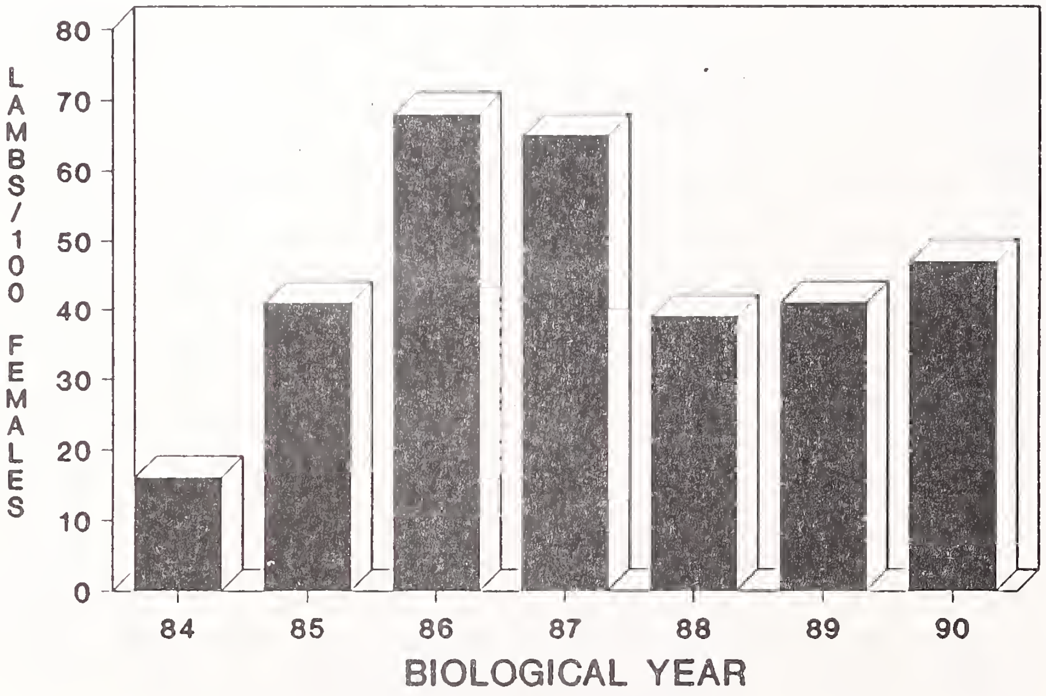


Figure 8. Number of lambs:100 females, Ural-Tweed bighorn sheep population, 1984 to 1990.

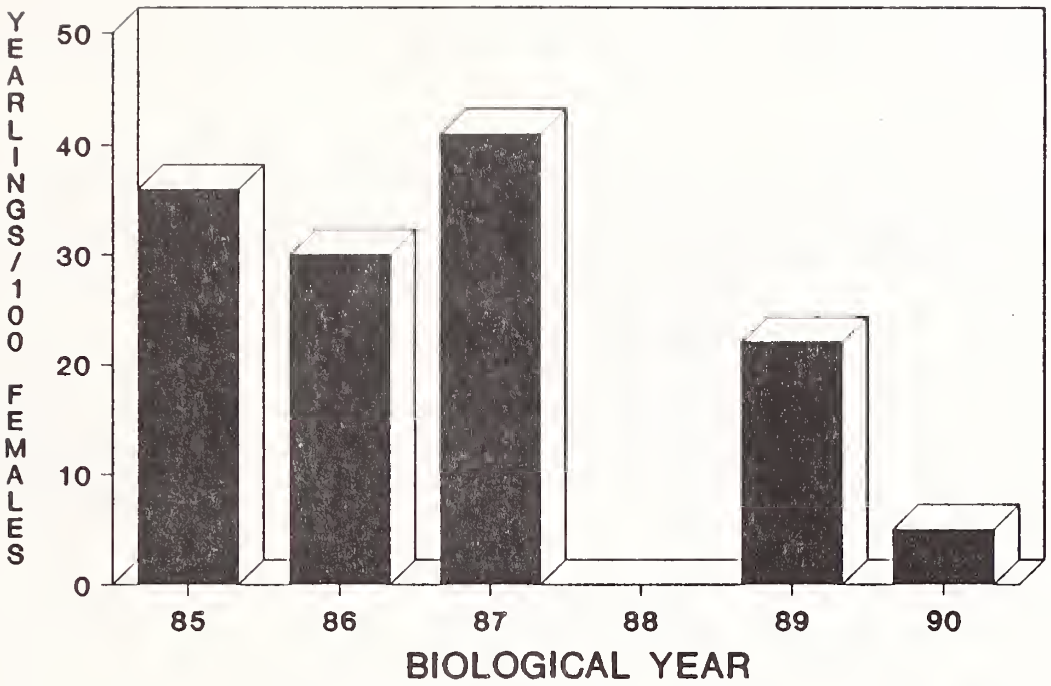


Figure 9. Number of yearlings:100 females observed in the Ural-Tweed bighorn sheep population.

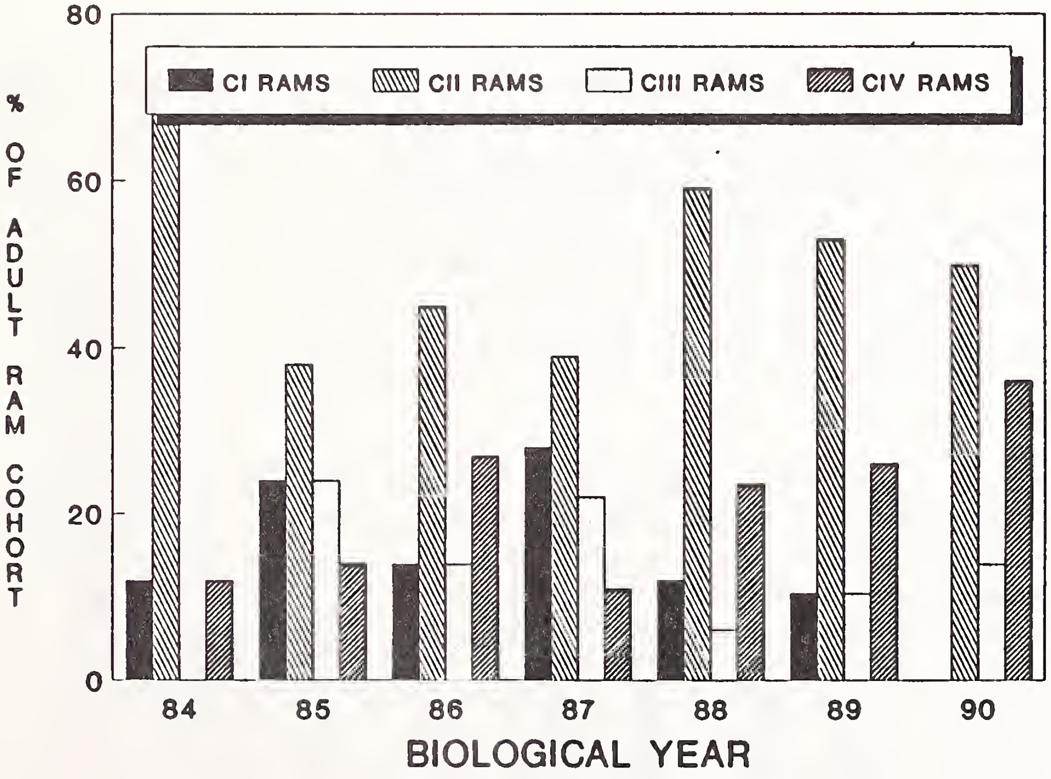


Figure 10. Number of rams in the four adult male categories (Geist 1975).

of project personnel. Additionally, observation rates of marked yearlings were very low (1-4 observations of a marked yearling/yr) and indicated yearlings may not be as visible as other age classes. Because of the reduced sample size, the number of yearlings in the population and recruitment rates were probably underestimated.

The proportion of adult males in the population has remained fairly stable throughout the project (Fig. 7), ranging from 17-25%. We classified males into five categories, based on age and horn growth (Geist 1975). The percentage of the male cohort in each of the categories is shown in Fig. 10. The percent yearlings and Class III rams in the population, while fluctuating, has remained fairly stable. The proportion of Class IV rams has increased over time, while the percentage of Class II and Class III rams has decreased since the project was initiated. Class II rams are wanderers and may be missed or under-represented in field surveys. Additionally, increased horn growth rates have been observed since 1984. This may have resulted in the mistaken classification of younger rams into older age categories.

In 1990, three any ram permits were offered for the Ural-Tweed population. A success rate of 100% was obtained by the three hunters. The harvested rams ranged from 5.5 to 11.5 years of age. Two of the rams had been radio-collared during the project. Both of these collars were functioning only as neck bands as the electronic components had quit working. Based on the increase in the population size and the overall number of rams in the population, we recommend the season continue.

Mule deer

We developed two population estimates for the mule deer population inhabiting the Ural-Tweed winter range. For the February 1990 survey, the mule deer population estimate was 1,140 ± 538, and for the December 1990 survey the estimate was 1,322 ± 566. These estimates indicate similar population levels for the two years; however, the 95% CI for the estimates were very wide. A low proportion of the marked animals was observed during each of the surveys (23% in February and 28% in December). This is the primary cause of the wide confidence levels. For the December survey, a separate population estimate was developed for the winter range segment between Tenmile Creek and Rocky Gorge (721 ± 318). Again a wide 95% CI existed.

During the December 1990 helicopter survey, a total of 406 mule deer were classified. For the entire winter range the fawn:100 females:males was 48:100:22. The fawn:100 females in the Tenmile Creek (52:100), Sutton Creek (64:100) and McGuire Creek (69:100) segments were significantly higher than in the Allen Gulch/Rocky (34:100) and Tweed Creek (28:100) winter range segments.

Sex and age distribution data was obtained from trapped animals (Fig. 11). A total of 138 mule deer were captured from 1987 through 1989. This total includes 107 animals marked and released, 8 animals recaptured a subsequent biological year, 14 animals released without handling, and 9 mortalities. Distribution of females by age class indicates similar proportions of individuals in years 1 through 6. A slight increase in the proportion in age classes 3 and 4 was observed. The 1 and 2 year old does were apparently under represented in

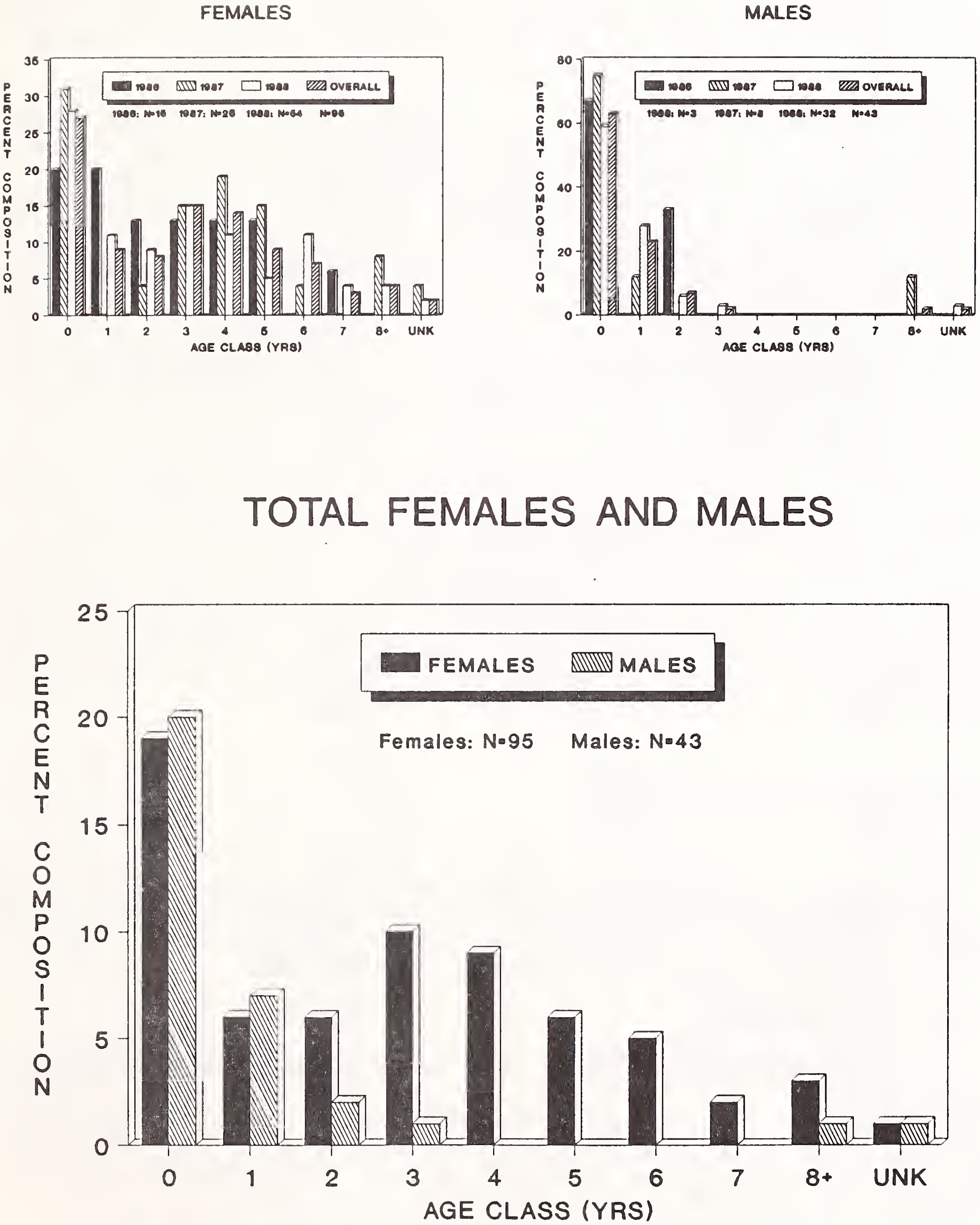


Figure 11. Age distribution of mule deer captured on the Ural-Tweed winter range, 1987 to 1990.

the distribution of captured animals. The age distribution indicates the population in probably static. This is further supported by the low fawn:100 females ratios which we observed.

Younger males were more susceptible to trapping than the older males. This may have been a factor of male distribution on the winter range. Older males tend to stay at higher elevations and are therefore less available for trapping. This distribution is similar to that reported by Hornocker (1970).

Age distribution of hunter harvested mule deer from the Koocanusa Bridge check station was compiled for Hunting District 100 (west side of Lake Koocanusa) and Hunting Districts 101 and 103 (east side of Lake Koocanusa). Number of harvested animals from HD 100 was sufficient to provide an annual age class distribution (Fig. 12). An insufficient number of animals was harvested from HD 101 to provide age distribution. These data indicate there is a greater proportion of younger aged animals in the population than observed during trapping on the Ural-Tweed range. This indicates a higher recruitment rate may exist in HD 100 than that observed on the east side. The small number of harvested animals from HD 101 indicates hunters are probably selecting older aged males (Fig. 13). This corresponds to hunter interviews indicating the majority of hunters primarily pursue mature bucks when hunting on the Ural-Tweed range.

An objective of the project is to determine population response to the habitat enhancement efforts. Accuracy of the population estimates should therefore be increased. We suggest survey efforts be concentrated in the winter range segment between Tenmile Creek and Rocky Gorge. Increased sampling effort - time and intensity - should provide improved results. Additionally, the number of marked animals on the winter range segment (active radio collars) should be increased. A corresponding increase in the total number of animals and number of marked animals observed should result. An increase in sampling intensity should result in the proportion of marked animals observed. This will narrow the confidence limits around future population estimates.

Animal movements and distribution

Bighorn sheep

A summary of bighorn sheep distribution and movement patterns was presented in Yde and Coates (1990). Further analysis of the relocation data has not been completed. Data analysis to determine home ranges, activity centers and animal selection of habitat parameters is scheduled for this year.

Mule deer

Mule deer inhabiting the project area were distributed among 3 tentative population-habitat units (PHU's)(Fig. 14). A PHU is "a rather discrete association of individual deer bonded together by traditional use of individual home ranges within a definable unit of yearlong habitat" (Pac et al. 1991). The winter range of each PHU is the nucleus of the unit and deer migrate from it to the boundaries of each PHU.

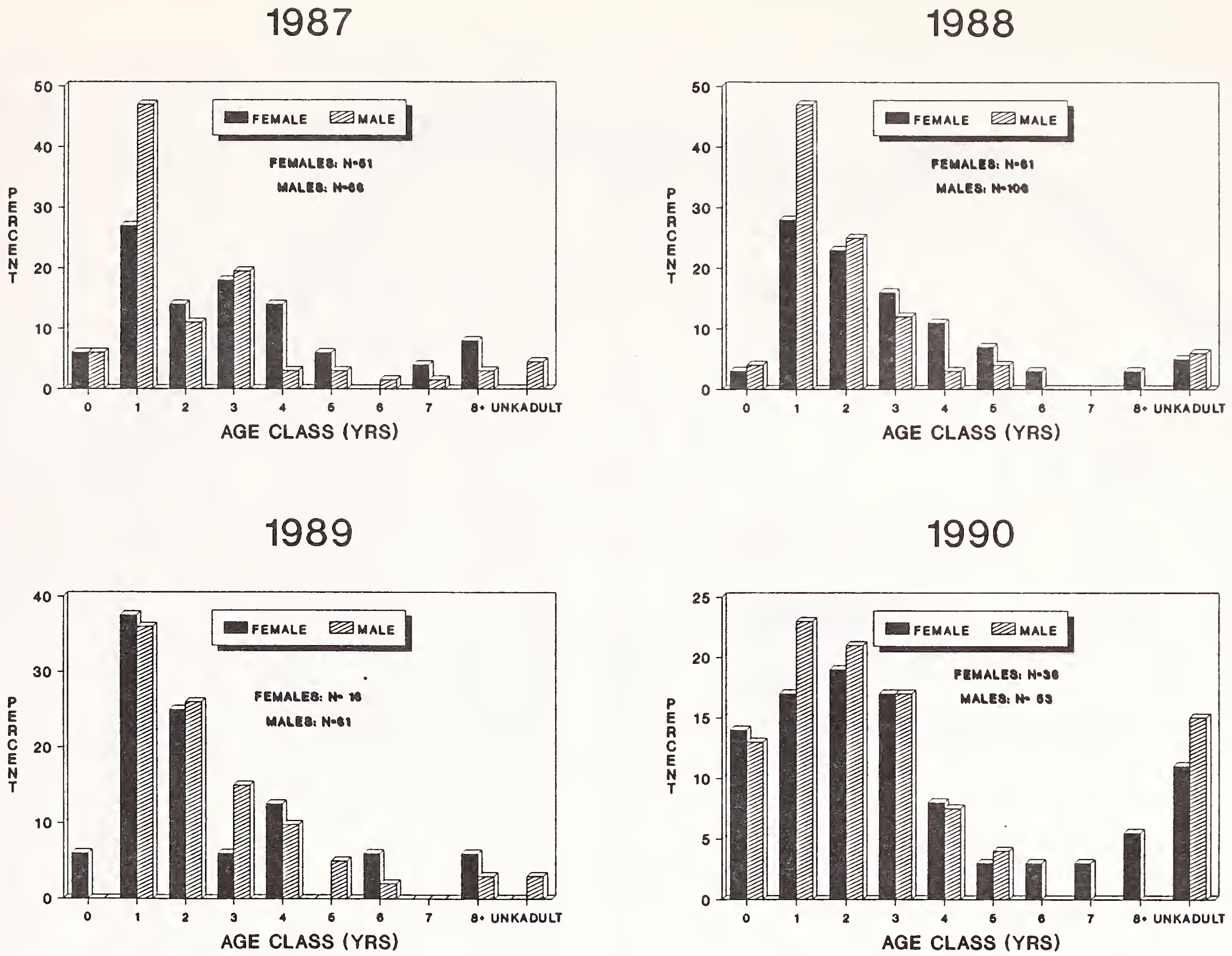


Figure 12. Age distribution of hunter harvested mule deer (HD 100) checked at the Koocanusa Bridge check station, 1987 to 1990.

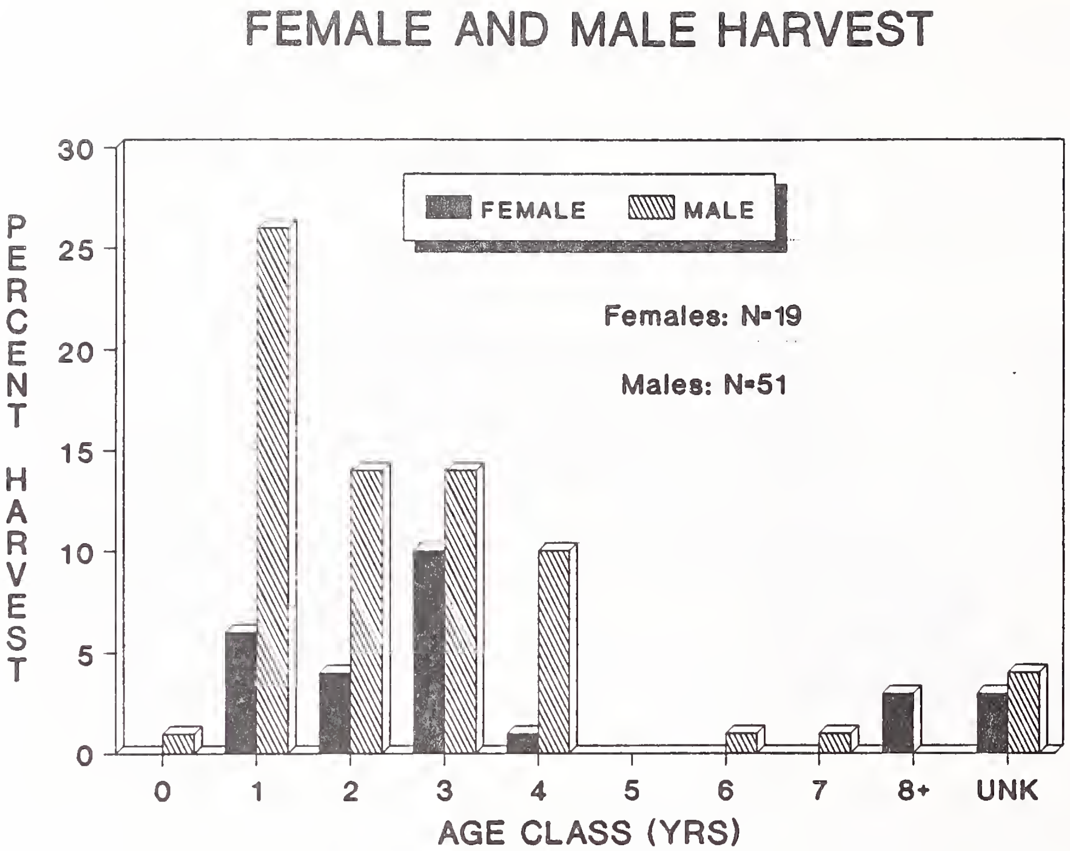


Figure 13. Age distribution of hunter harvested mule deer (HD 101 and 103) checked at the Koocanusa Bridge check station, 1987 to 1990.

PHU 1 (165.3 km^2) encompasses the winter range from Tenmile Creek to Rocky Gorge. It extends from Lake Koocanusa up the Tenmile Creek drainage and into the upper end of Pinkham Creek. The upper reaches of Sutton and McGuire Creeks are also in PHU 1. Forty two instrumented deer used this PHU.

Based on the home range analysis of the instrumented deer in this PHU, we split the winter range into 3 segments. Sub-unit 1a extends along the face from Tenmile Creek to Sheep Creek. Sub-unit 1b encompasses the area from Sheep Creek to just north of Allen Gulch, while sub-unit 1c extends from Allen Gulch to Rocky Gorge. There were 15, 17 and 10 instrumented deer on 1a, 1b and 1c, respectively. As deer migrated from the winter range, a considerable amount of intermixing took place between different sub-units.

Summer range consists of several interspersed cover types. Lodgepole pine occurs in large homogeneous stands, or in smaller stands mixed with western larch and sub-alpine or Englemann spruce. Douglas fir is an important component on parts of the summer range, especially adjacent to the winter range. In addition, there are several timber harvest units of varying sizes scattered through the PHU.

PHU 2 is 10.6 km^2 with 6 instrumented mule deer. This PHU is situated in McGuire Creek and extends half-way up the drainage. Winter range is limited to south-facing slopes along the lower third of the drainage. The winter range

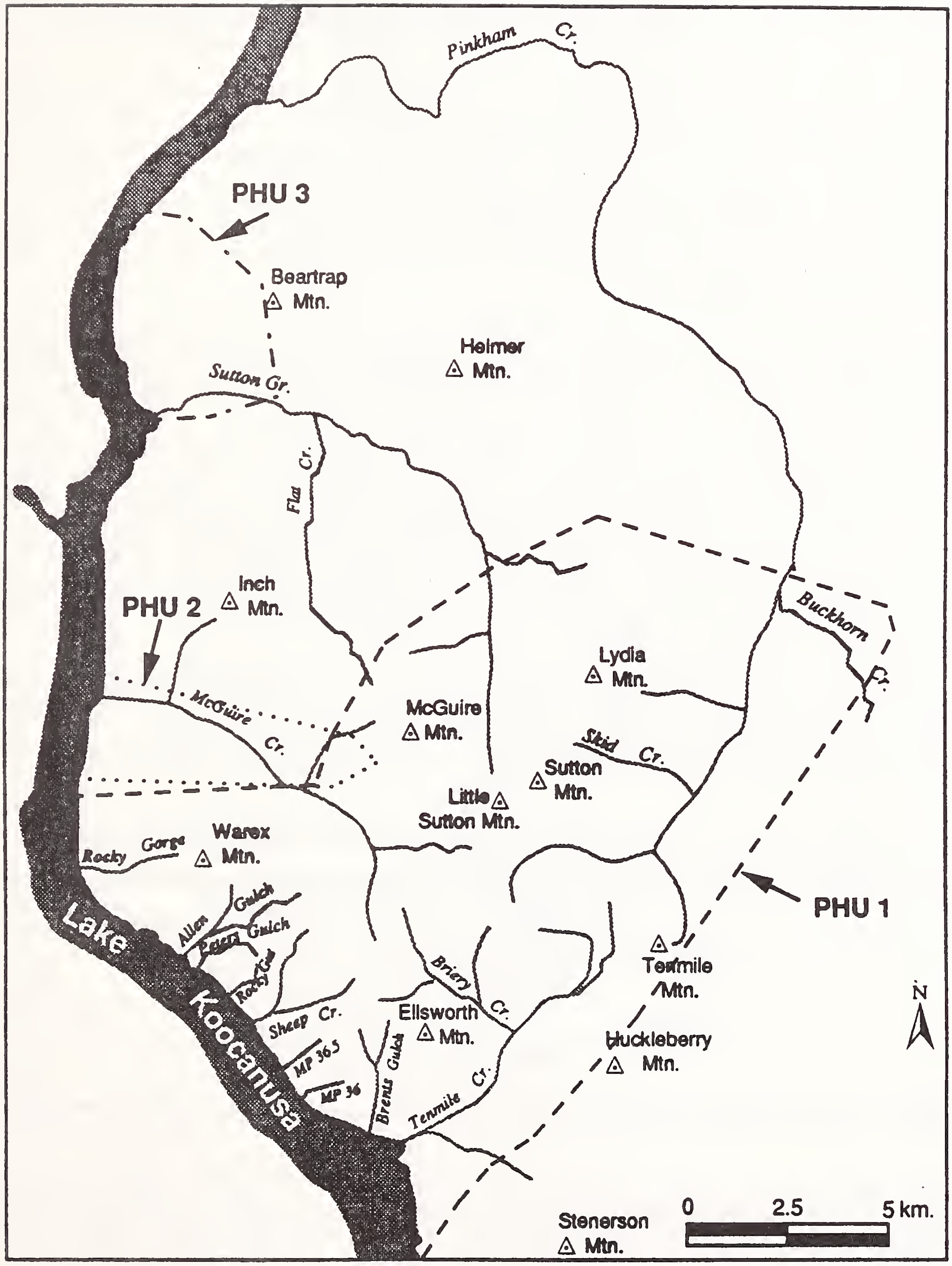


Figure 14. Three mule deer population - habitat units (PHU's) associated with the Ural-Tweed winter range.

consists of a mixed stand of ponderosa pine and Douglas fir which has been selectively harvested. Summer range is characterized, almost exclusively, by lodgepole pine. Several harvest units are interspersed throughout.

PHU 3 is 13.9 km^2 and has had up to 7 instrumented mule deer. It covers the western slope and part of the top of Stone Hill. Since all 7 of the instrumented deer on this unit are residents, it is not possible to delineate separate summer and winter ranges. The upper portions of the unit are characterized by Douglas fir and western larch mixed with lodgepole pine. Ponderosa pine characterizes the lower portions of the unit. A relatively large portion of the unit is covered by natural, grassy openings or cliffs, rocky outcrops and talus slopes.

We identified three categories of mule deer based on distances separating seasonal ranges. This is similar to work completed on other mule deer ranges in Montana (Pac et al. 1991). The first category is deer that have indistinct seasonal ranges (ISR deer). These deer are residents of all or a portion of the winter range for the entire year. There is an equal probability of finding relocations from any season on any portion of the home range. The second category of deer have adjacent seasonal ranges (ASR deer). Winter and summer ranges of these deer are clearly distinguishable, but are usually no more than 1.0 to 1.5 km from each other. Deer in this category frequently drift back to the winter range. The third category of deer has distinct seasonal ranges (DSR deer). Seasonal ranges of these deer are separated by at least 1.5 km. These three seasonal distribution patterns are illustrated by Fig. 15.

We assigned 54 female mule deer to one of 3 categories based on their movements over at least one year (Table 4). A lot of variability in the number of deer in each category existed among PHU's. PHU 1 had 10 ISR deer, 11 ASR deer and 23 DSR deer. PHU 2 had five DSR deer, while PHU 3 had 7 ISR deer.

Table 4. Percentage of instrumented mule deer in each movement pattern for each PHU and for all PHU's combined.

PHU	ISR	ASR	DSR
1	23.3	23.3	53.5
2	0.0	0.0	100.0
3	100.0	0.0	0.0
Total	30.4	19.6	50.0

In addition to the 3 seasonal-range movement patterns, individual deer movements vary in the use of accessory areas (Pac et al. 1991). Accessory areas are separated from seasonal home ranges by 0.4 km to 35 km. Deer spend from 5 to 105 days on the accessory areas. ISR deer, using fall accessory areas, spend the most time on accessory areas. DSR deer with fall accessory areas spend the second longest amount of time on their accessory areas. Deer with spring and

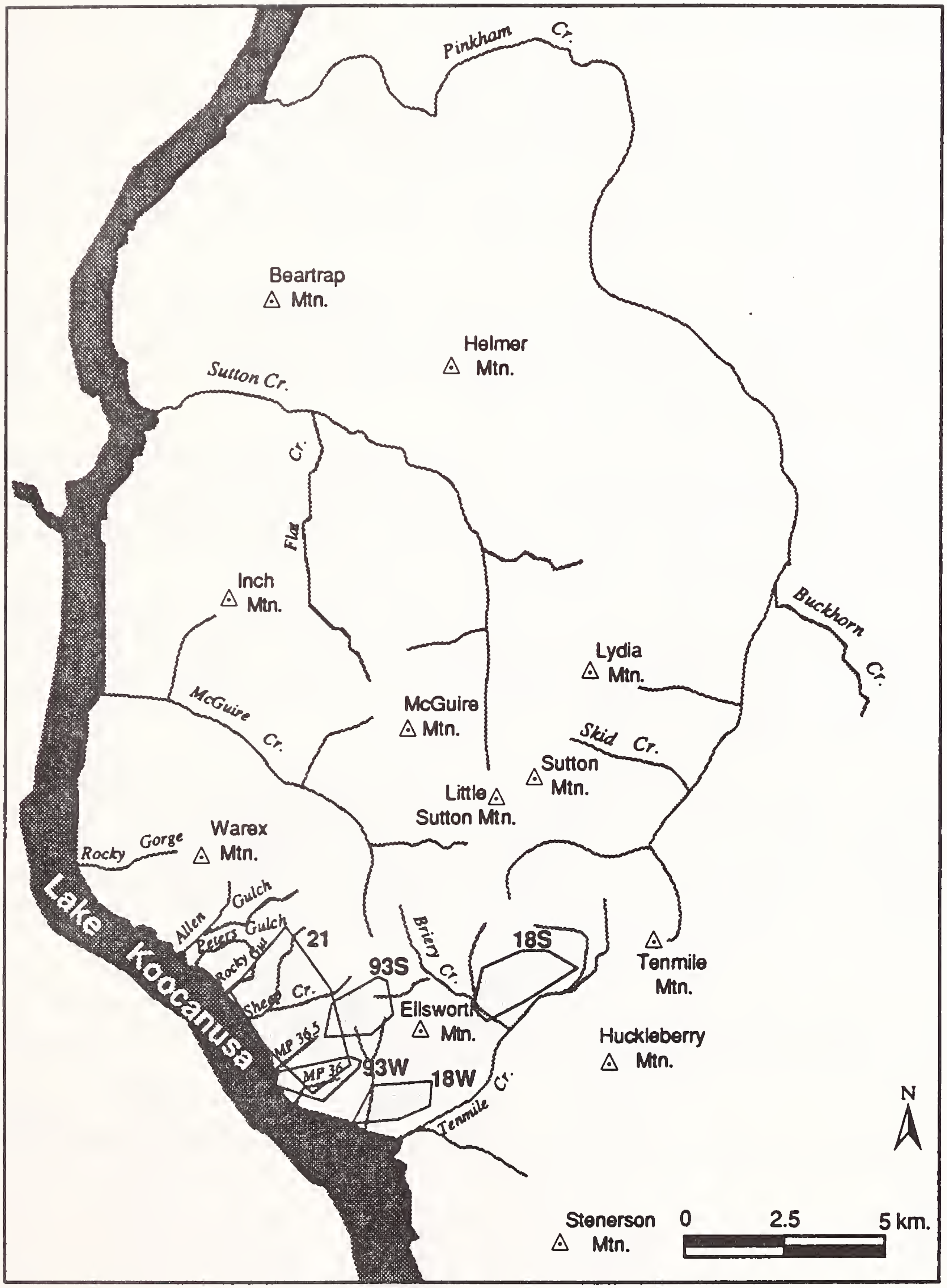


Figure 15. Winter and summer home ranges for 3 instrumented mule deer which illustrate ISR (Deer #21), ASR (Deer #93) and DSR (Deer #18) movement patterns.

summer accessory areas usually occupy these areas ≤ 30 days, regardless of their movement pattern.

Movements or migrations between seasonal ranges do not appear to occur along any particular corridor (Fig. 16). Most instrumented animals move in an east to northeast direction when moving from winter to summer range. The longest movement observed to date has been 35 km to a fall accessory area by deer 15 from PHU 1. The shortest movements are 1 km or less by several instrumented deer in PHU 1 moving from winter to summer range. The overall mean distance between seasonal ranges in PHU 1 and 2 is 6.6 km.

In 1988, deer left winter ranges earlier, but returned later than in 1989. During 1988, mean date of departure from the winter range was June 1 for all instrumented animals. This was 7 days earlier than the mean departure date in 1989. The mean date of return to the winter range was November 11 in 1988, about 21 days later than the mean date for 1989.

Departure dates from winter to summer range were about the same for deer in the ASR and DSR movement patterns. This was approximately June 1 in 1988 and June 6 in 1989. ASR deer departed from summer range approximately December 11 in 1988, more than a month later than DSR deer. ASR deer returned to winter range at least 1 month later than DSR deer in 1989 as well.

All instrumented deer showed a high level of fidelity to seasonal ranges. Only 2 deer shifted their use patterns between years. Deer #24 shifted her summer range between years, but remained on the same winter range. Deer #22 remained on the same winter range both years, but shifted from an ISR pattern in 1988 to and ASR pattern in 1989.

Summer home range sizes and AAR for both years and for each PHU are given in Table 5. Winter home range sizes and AAR are presented in Table 6. Mean summer home range size for all deer decreased between 1988 and 1989. For PHU 1, the decrease was from 5.7, 1.9 and 4.6 km^2 to 3.2, 0.8 and 1.3 km^2 for ISR, ASR and DSR deer, respectively. The decrease was from 4.4 km^2 to 1.1 km^2 for ISR deer in PHU 3. We monitored deer in PHU 2 only during 1989. All declines between years were significant ($p<.05$).

Table 5. Mean summer convex polygon home range (PHR) sizes and average activity radii (AAR) for 1988 to 1989.

	1988			1989		
PHU	N	PHR(km^2)	AAR(km)	N	PHR(km^2)	AAR(km)
1 ISR	7	5.7	1.1	8	3.2	0.8
ASR	3	1.9	0.6	10	0.8	0.4
DSR	9	4.6	1.2	21	1.3	0.6
2 DSR				5	0.9	0.5
3 ISR	7	8.1	1.1	7	3.3	0.8

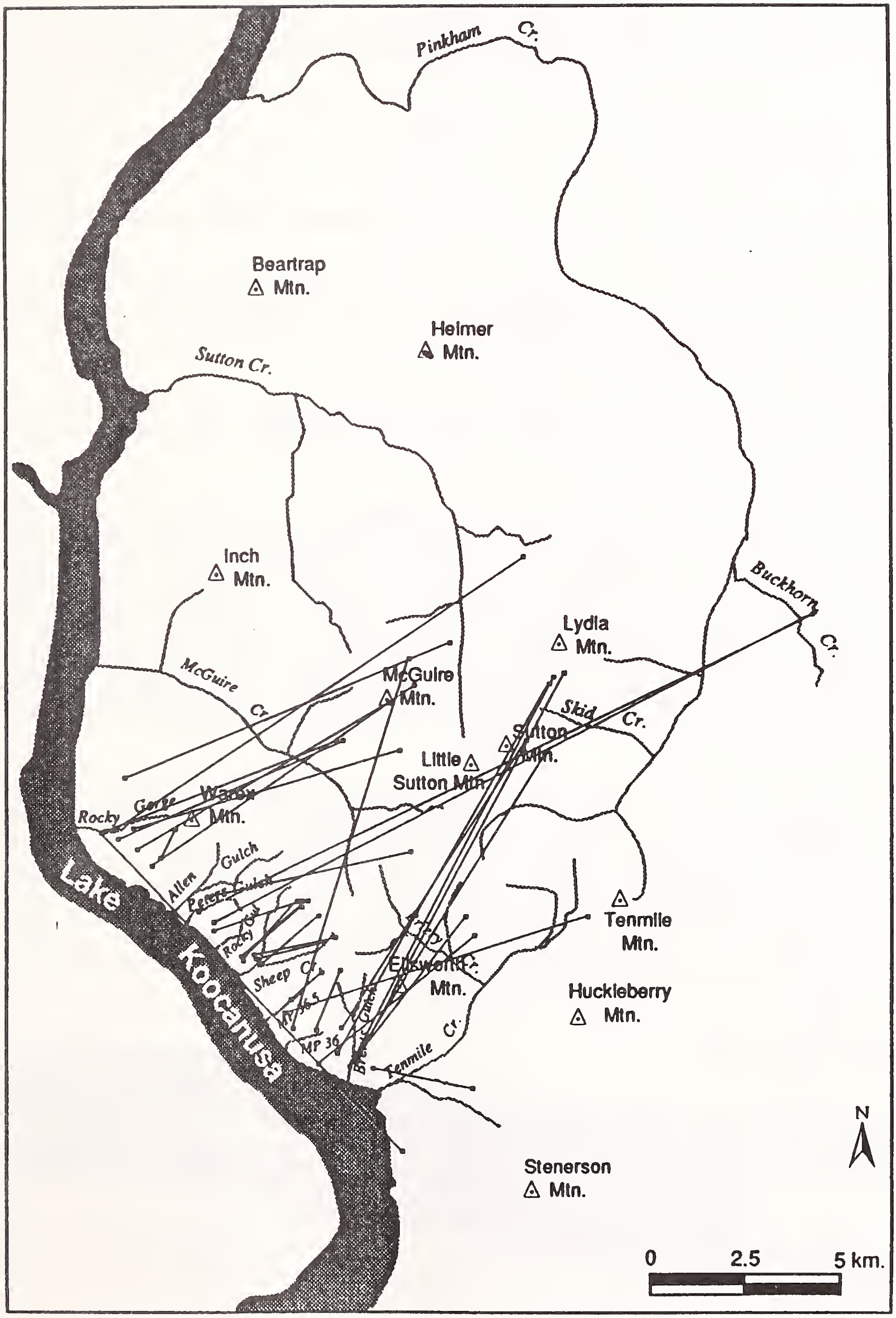


Figure 16. Location of winter and summer Geographical Activity Centers (GAC) for each instrumented deer in PHU 1.

Table 6. Mean winter convex polygon home range (PHR) and average activity radii for female mule deer in PHU 1 and 2, 1988 to 1989.

		PHR(km^2)		AAR(km)	
PHU	N	x	S.D.	x	S.D.
1	32	1.4	0.3	0.7	0.2
2	5	1.9	0.8	0.8	0.3

Mean AAR for PHU 1 deer decreased between years from 1.1, 0.6 and 1.2 km to 0.8, 0.4 and 0.6 km for ISR, ASR and DSR deer, respectively. Mean AAR for deer in PHU 3 decreased from 1.0 km to 0.6 km. The decrease for both movement patterns was significant ($p<.05$).

Mean home range size and mean AAR for winter were compared between PHU 1 and 2. There was no significant difference between the PHU's for either measurement ($p>.05$).

Mean home range size and AAR for summer were compared between movement patterns and PHU's for both years. During 1988, only ISR deer were compared between PHU 1 and 3. There were no ASR or DSR deer monitored in PHU 2 during 1988 to compare with ASR and DSR deer in PHU 1. Home range size was significantly larger ($p<.05$) for ISR deer in PHU 3. There was no significant difference ($p>.05$) between AARs. During 1989, there was no significant difference ($p>.05$) between ISR deer in PHU's 1 and 3 for either measurement. Measurements for ASR and DSR deer were pooled in PHU 1 and compared to DSR deer in PHU 2. There were no significant differences ($p>.05$) between the two PHU's for either measurement.

Deer of different age and sex had different sized home ranges. Generally, fawns and yearlings had larger home ranges than adult females. Younger females also tended to have more random movements throughout the summer. For example, #19 moved more randomly in 1988 as a fawn than in 1989 as a yearling. In several instances, it appears we captured more than 1 individual from an associated family group. Overlapping summer home ranges indicate the females were probably related. Summer home ranges of 5 instrumented female mule deer in PHU 2 are illustrated in Fig. 17. We captured these animals between 8 and 11 January 1989. Their ages at capture ranged from 1 to 8 years.

Summer habitat use.

Relative occurrence of the 6 cover types, by PHU, is given in Table 7. Lodgepole pine and mixed conifer compose most of PHU 1. Mixed conifer alone makes up 63% of PHU 2. Nearly 60% of PHU 3 is composed of mixed conifer. It also has the largest amount of non-forested areas.

Relative mule deer use of each cover type, by PHU, is presented in Table 8. Coefficients of variation are included to give a measure of variation of cover type use within PHU's. Use of lodgepole pine and mixed conifer were about

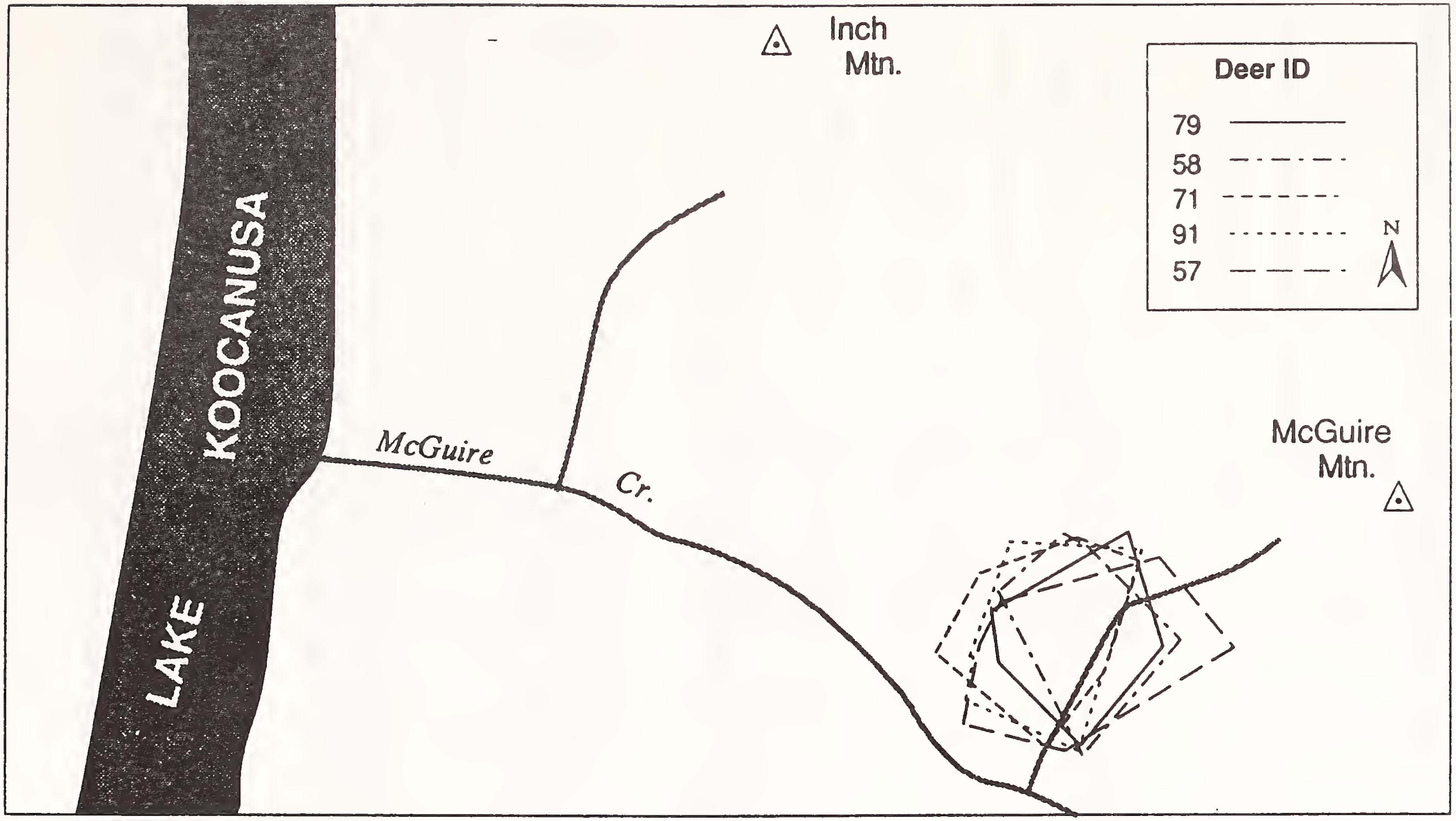


Figure 17. Location of 5 over-lapping summer home ranges for DSR deer in PHU 2.

Table 7. Relative occurrence of cover types in each PHU.

PHU	NS[1]	LPP	MC	SAF	PP	NF
1	15.7	27.8	30.0	20.9	3.7	1.6
2	3.4	27.1	63.3	0.0	4.9	1.4
3	9.8	5.5	59.3	0.6	9.7	15.1

[1] Cover types are abbreviated as: NS=non-stocked, LPP=lodgepole pine, MC=mixed conifer, SAF=sub-alpine fir, PP=ponderosa pine, and NF=non-forested.

Table 8. Relative use of cover types and coefficients of variation (C.V.)[1] in each PHU for summers 1988 and 1989.

Cover Type[2]	PHU 1		PHU 2		PHU 3	
	%	C.V.	%	C.V.	%	C.V.
NS	14.1	96	25.0	44	4.4	133
LPP	27.2	75	65.4	12	1.0	125
MC	29.4	128	9.6	0	59.5	18
SAF	16.3	163	0.0	0	0.0	0
PP	8.5	229	0.0	0	13.5	51
NF	4.5	205	0.0	0	21.6	79

[1] C.V.=S.D.(100)/x

[2] See Table 7, above, for definitions of cover type abbreviations.

equal in PHU 1. The most heavily used cover type in PHU 2 was the lodgepole pine type. Mixed conifer was utilized the most in PHU 3, with non-forested areas receiving secondary use. Variation in use of cover types was lowest for lodgepole pine in PHU 1 and 2, and mixed conifer in PHU 3.

Percent use and C.V.'s of cover types for each movement pattern are given in Table 9. Use of cover types varied among deer following different movement patterns. More than 50% of use by ISR deer occurred in the mixed conifer type. In contrast, lodgepole pine accounted for more than half of the use by ASR deer. Lodgepole pine and sub-alpine fir types received heavy use by DSR deer. Variation was least for DSR and ASR deer in lodgepole pine types, and ISR deer in mixed conifer.

Cover type use in summer versus availability analysis was conducted on all 3 PHU's. A summary of chi-square analysis for cover type use is presented in Table 10. In PHU 1, sub-alpine fir was used less than expected, while ponderosa pine and non-forested were used more than expected ($p<.01$). The other three types were used in proportion to their availability. In PHU 2, non-stocked and lodgepole pine were used more than expected and mixed conifer was used less than

Table 9. Relative use of cover types and coefficients of variation, by movement pattern, for summers 1988 and 1989.

Cover Type[1]	ISR		ASR		DSR	
	%	C.V.	%	C.V.	%	C.V.
NS	4.9	129	15.5	87	21.8	82
LPP	7.3	137	52.3	55	33.5	66
MC	53.7	43	23.2	74	14.4	146
SAF	0.7	239	7.7	145	29.3	139
PP	17.6	65	0.0	0	0.5	529
NF	15.8	98	1.3	332	0.5	367

[1] See Table 7 for definitions of cover type abbreviations.

expected (p<.01). In PHU 3, non-stocked and lodgepole pine were used less than expected and non-forested was used more than expected (p<.01). Mixed conifer and ponderosa pine were used in proportion to their availability.

We summarized use of aspect (Fig. 18) and slope (Fig. 19) across the three PHU's by animal movement pattern. Instrumented mule deer demonstrated a preference for south- to west-facing slopes. ISR and ASR deer showed a greater selection for these aspects than did DSR deer. DSR deer showed greater use of all aspects than did deer from the other two movement patterns. ISR and ASR deer used the moderate (13 - 19°) to steep (≥20°) slopes more than DSR deer. These deer preferred gentle (6 -12°) to moderate slopes.

Use versus availability analysis also was preformed on the aspect and slope data for PHU 1 (Table 10). North, east, northeast, southeast and northwest exposures were generally used less than expected (p<.01). Southwest and west exposures were used more than expected (p<.01) and south exposures were used in proportion to availability. Gentle slopes were used less than expected (p<.01). Steep slopes were used more than expected (p<.01). Level and moderate slopes were used in proportion to availability.

Mean elevations used by animals in each of the movement patterns by PHU are presented in Table 11. ISR deer had the lowest mean elevations for the 3 movement patterns. ASR deer demonstrated use of the highest mean elevation.

Browse utilization

Browse utilization transects were conducted in the spring of 1985 through 1989. Utilization data are summarized in Appendix A. In general, browse utilization has increased in both the treatment and control areas since initiation of habitat enhancements. The increase in the treatment areas has been greater than in the respective control area. The increased browse utilization

Table 10. Summary of Chi-square analysis to evaluate use vs availability of cover types, aspect and slope during summers 1988 and 1989.

Environmental Variable	PHU		
	1	2	3
Cover Types[A]			
NS	0[B]	+[C]	-[D]
LPP	0	+	-
MC	0	-	0
SAF	-		
PP	+		0
NF	+		+
Aspect[E]			
N	-		
NE	-		
E	-		
SE	-		
S	0		
SW	+		
W	+		
NW	-		
Slope			
Level	0		
Gentle	-		
Moderate	0		
Steep	+		

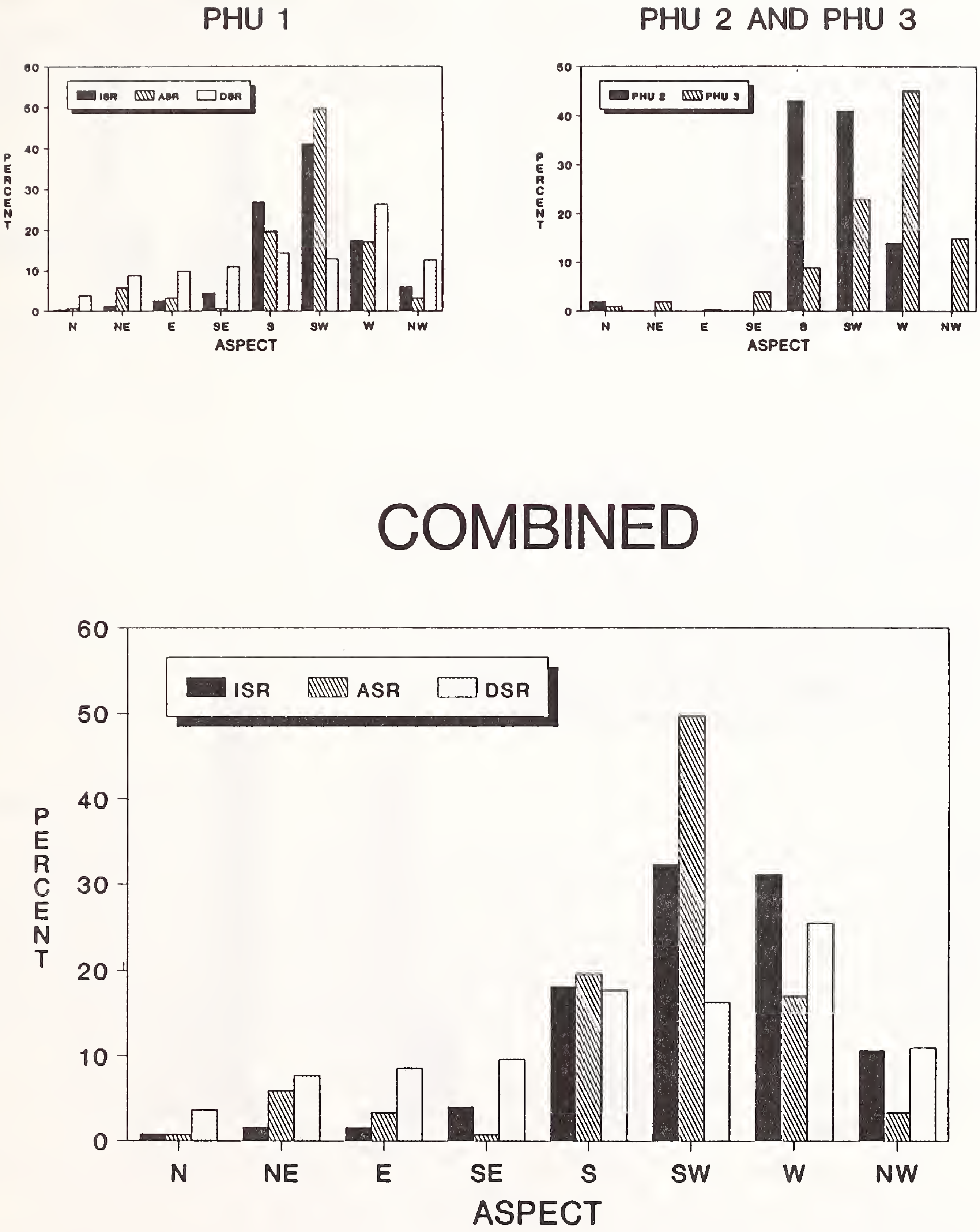
[A] Definitions of cover type abbreviations are include in Table 7.

[B] 0 = use in proportion to availability.

[C] + = use greater than expected by chance.

[D] - = use less than expected by chance.

[E] Availability of aspect and slope were not calculated for PHU 2 and 3.


PHU 1

PHU 2 AND PHU 3

COMBINED

Figure 18. Selection of aspect by radio-collared mule deer in the 3 PHU's and 3 movement patterns.

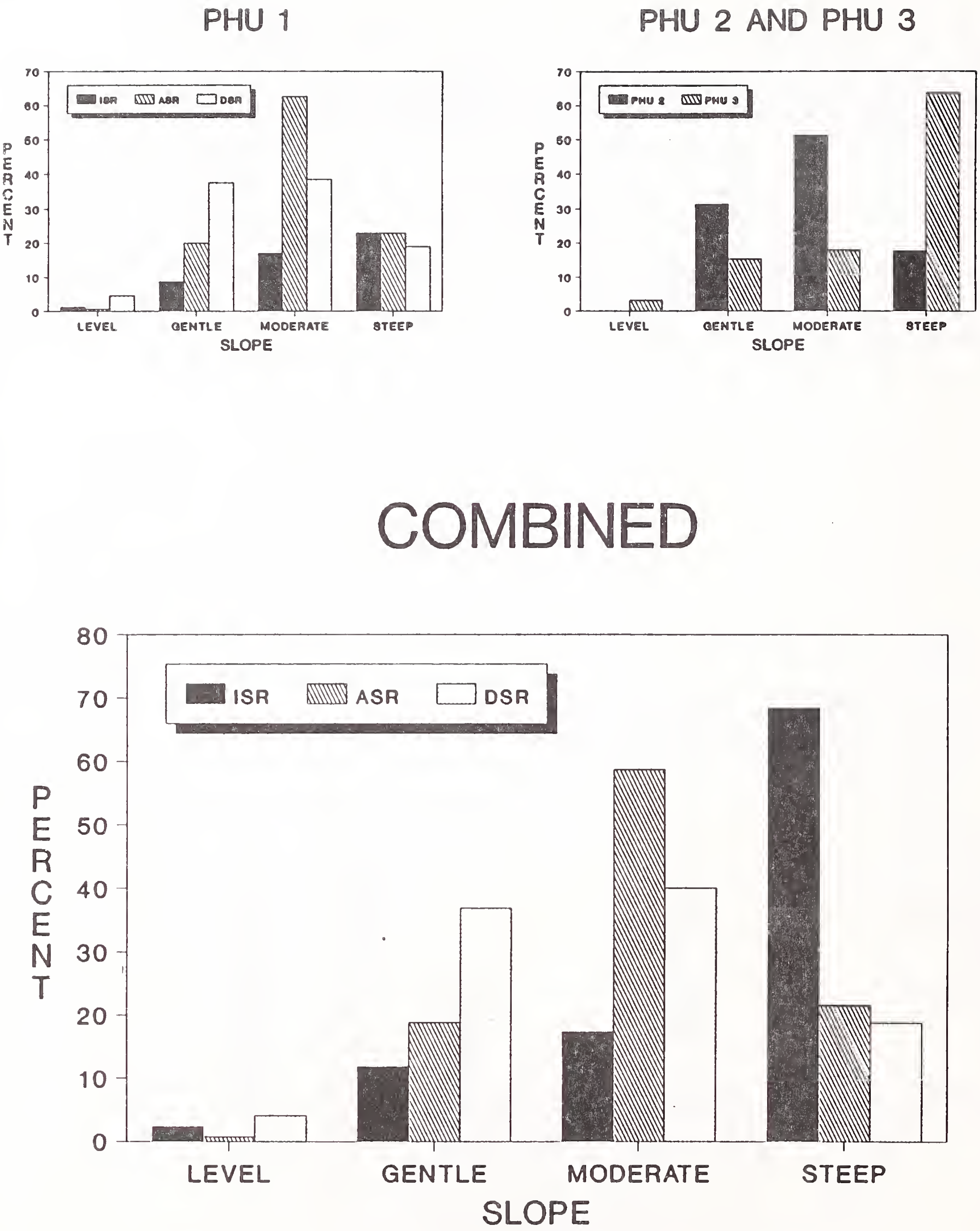


Figure 19. Selection of slope by radio-collared mule deer in the 3 PHU's and 3 movement patterns.

Table 11. Mean elevations (m) of mule deer relocations for all movement patterns and PHU's during summers 1988 and 1989.

PHU	ISR	ASR	DSR
1	1196	1699	1673
2	----	----	1587
3	1112	----	----
Combined	1154	1699	1630

is related to a shift in animal use patterns and/or an increase in the size of the populations inhabiting the project area.

Pellet group surveys

These surveys have been conducted in conjunction with spring browse utilization surveys, as well as, summer vegetation production and diversity surveys, 1985 through 1990. The number of pellet groups per plot was highly variable; however, the general trend was an increased number of pellet groups/ha in both the treatment and control areas (Fig. 20, Appendix B). The increase in the treatment areas was greater than in the respective control area. The increased use of the control areas, as indicated by an increased number of pellet groups/ha, was probably related to the increased number of animals using the treatment areas. Increased use of the treatment areas probably resulted in increased incidental use (ie. traveling through) of the control areas. The use of the control areas for bedding and security areas has probably also increased.

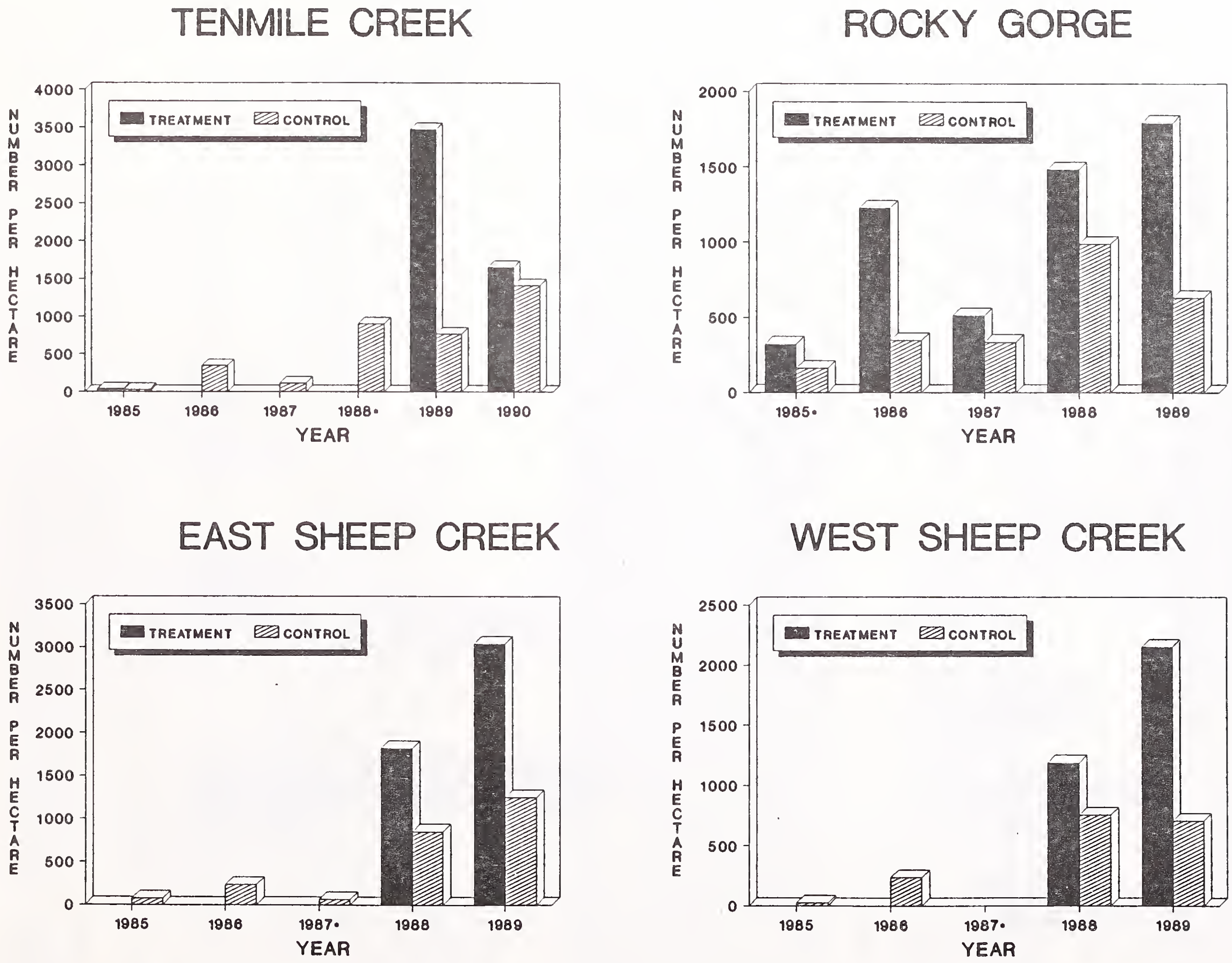
Vegetation monitoring

Beginning in 1985, vegetation data were collected from each of the treatment/control areas. Data were collected for at least one year pre-treatment and at least two years post-treatment (Table 11). In treatment areas where slashing occurred, accumulated material - in some cases 3-4 ft. deep - precluded vegetation data collection. Prescribed burning reduced accumulated material and post-treatment data collection was completed. In order to maintain a baseline data base for future comparisons, control areas for the slashed units were monitored during the treatment period.

Preliminary analysis of the shrub frequency and volume data was presented in Yde and Coates (1990).

Herbaceous forage production

Summaries of the herbaceous plant production are presented in Fig. 21 and Appendix C. The general trend in forage production paralleled the trends in browse utilization and pellet group frequencies. Increases in grass and forb


TENMILE CREEK

ROCKY GORGE

EAST SHEEP CREEK

WEST SHEEP CREEK

Figure 20. Summaries of pellet group surveys in treatment and control areas, 1985 to 1990. Treatment year designated by asterisk. Lack of bar indicates no data was collected.

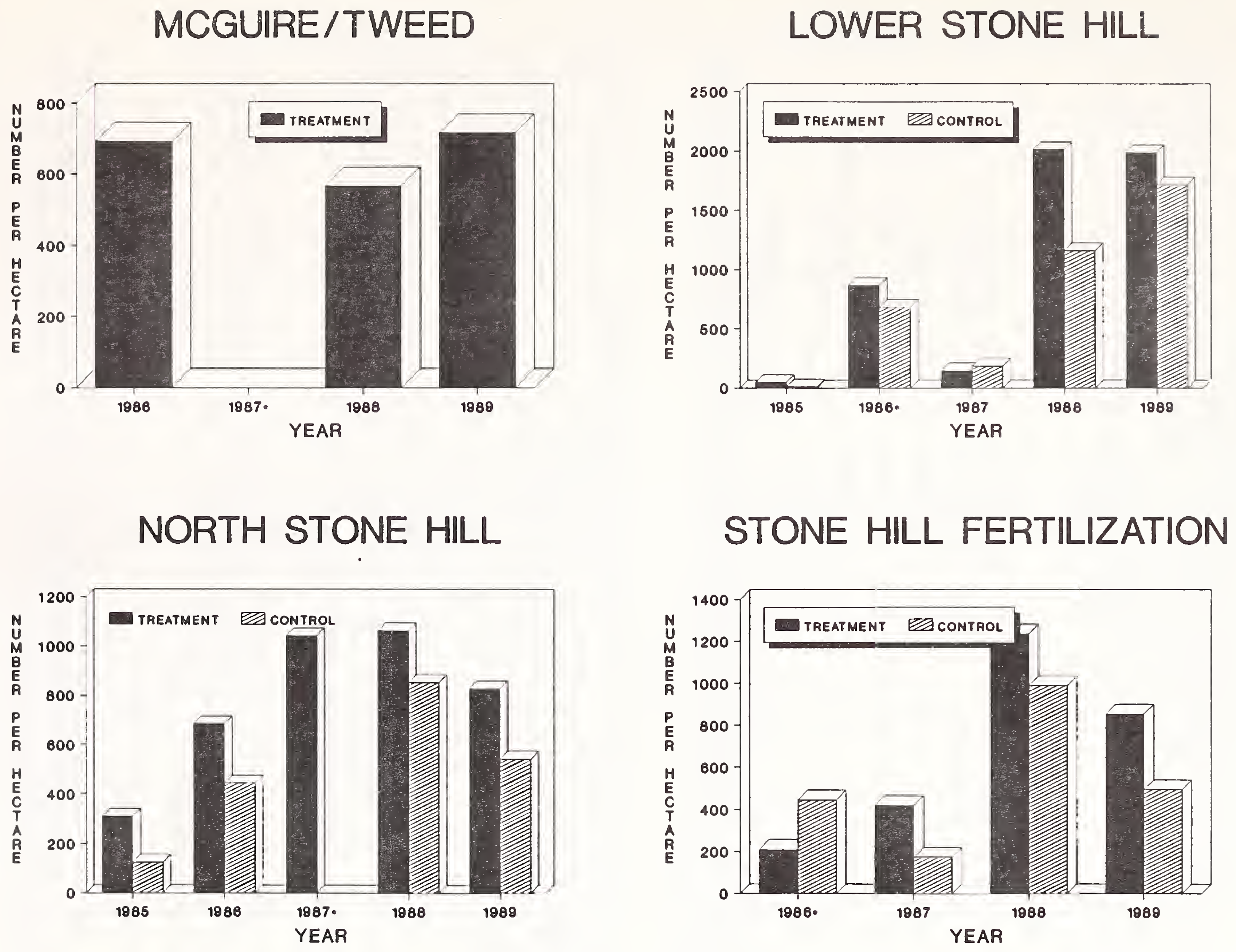


Figure 20 (continued). Summaries of pellet group surveys in treatment and control areas, 1985 to 1990. Treatment year designated by asterisk. Lack of bar indicates no data was collected.

Table 11. Summary of the vegetation monitoring schedule for the Libby Wildlife Mitigation Project, 1985 through 1990.

Treatment Area	Year					
	1985	1986	1987	1988	1989	1990
Tenmile	Pre[1]	Pre	None	Treat	Post	Post
South Sheep Creek						
East	Pre[1]	Pre[1]	Treat	Post	Post	None
West	Pre[1]	Pre[1]	Treat	Post	Post	None
Rocky Gorge	Post	Post	Post	Post	None	None
McGuire/Tweed	None	Pre	Treat	Post	None	None
Lower Stone Hill	Pre	Post	Post	Post	None	None
North Stone Hill	Pre	Pre	Treat	Post	Post	None
Stone Hill Fertilization	None	Pre	Post	Post	None	None

[1] Depth of slashed material precluded collection of vegetation data from the treatment areas.

production were observed in 7 of 8 areas following treatment. The North Stone Hill unit showed a slight decrease in grass production following treatment. This was probably related to the lack of a complete burn over the area. Many of the fixed plots in the treatment area experienced low intensity, incomplete burns or were not burned at all. Therefore, the expected increase in forage production following burning was not realized. Forage production in the Stone Hill fertilization unit increased in 1987, the year following treatment. However, production in the treatment and control areas in 1988, 2 years following treatment, was approximately the same. An increase in the forb production in the Rocky Gorge treatment area was realized 1 year following treatment. However, the response in grass production was not evident until the third year following treatment. The remaining treatments experienced an initial increase in herbaceous production following treatment.

Herbaceous plant production is closely tied to moisture patterns. Production fluctuates in response to increases or decreases in annual and seasonal precipitation. This explains some of the fluctuations in herbaceous production evidenced in Fig. 21.

Consultation and Coordination

The interagency cooperation between the USFS and MDFWP has been very extensive. Development of habitat treatments, treatment schedules and monitoring and evaluation methods have been coordinated between the two agencies.

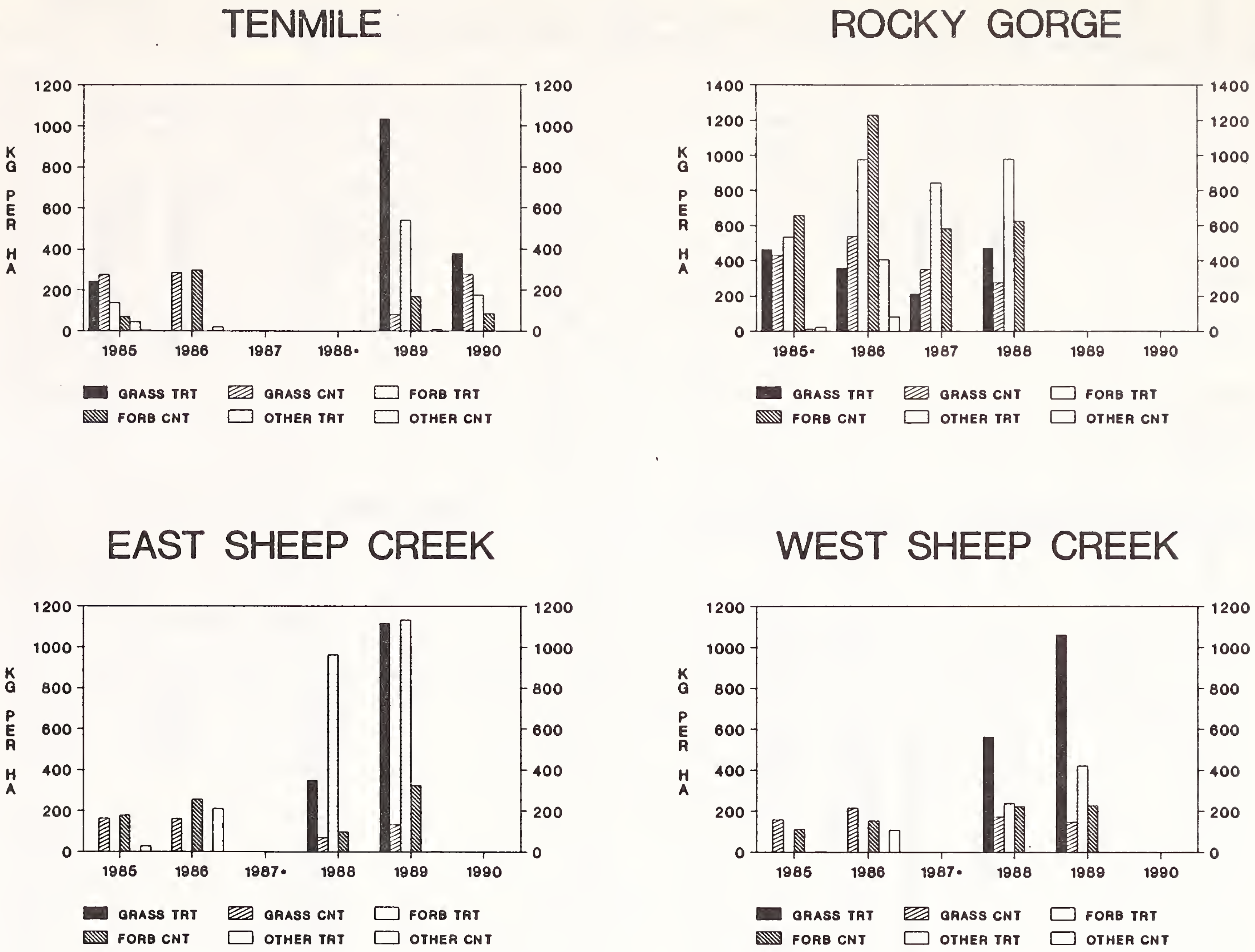


Figure 21. Summaries of herbaceous plant production in treatment and control areas, 1985 to 1990. Absence of bar indicates no data collected during a given year.

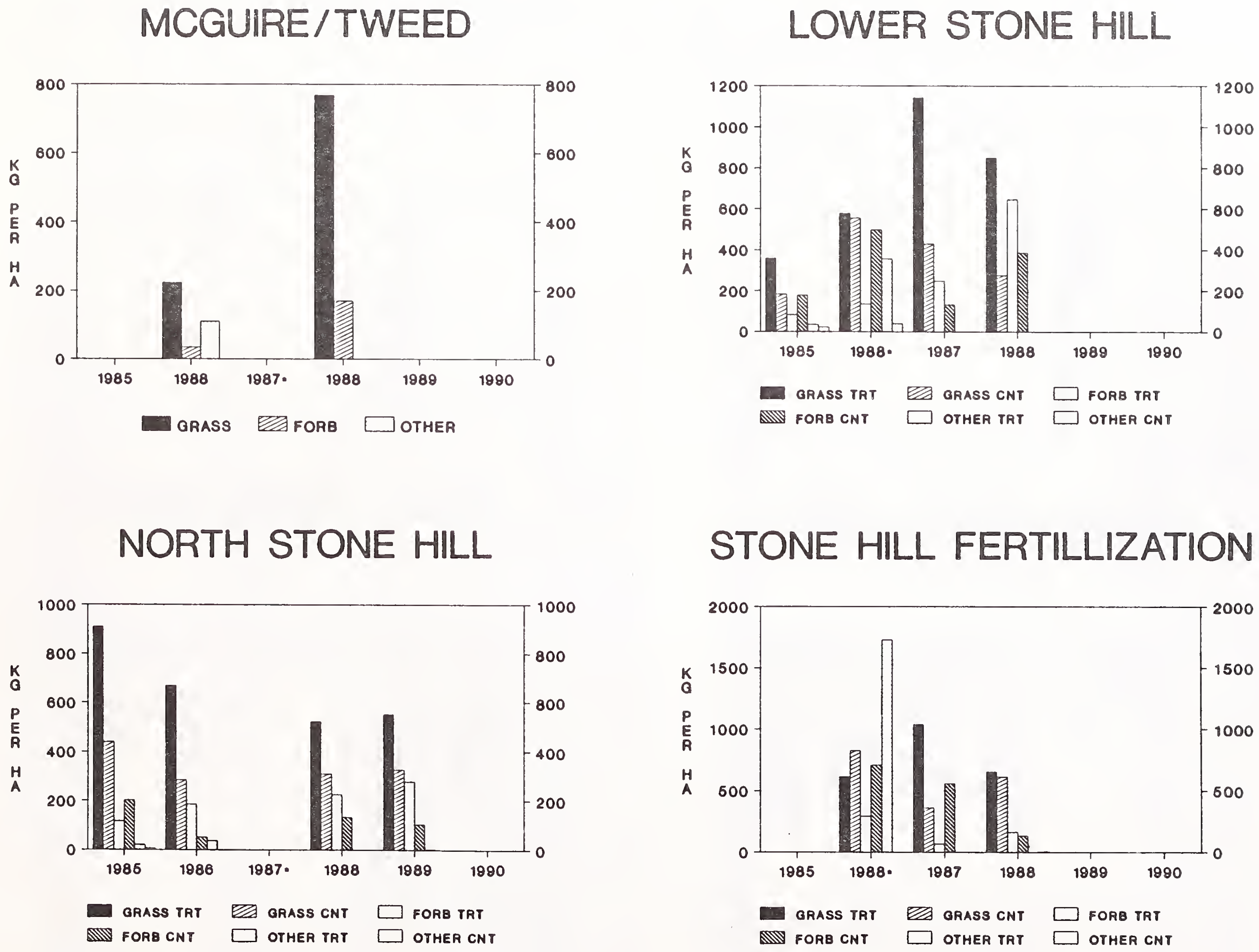


Figure 21 (continued). Summaries of herbaceous plant production in treatment and control areas, 1985 to 1990. Absence of bar indicates no data collected during a given year.

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APPENDIX A

Browse Utilization

Table 13. Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: Tenmile

	Treatment					Control				
	Year					Year				
Browse Species/ Percent Use	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
AMAL	5.9	---	---	---	39.1	4.7	52.9	4.5	21.1	26.3
ROSA	15.3	---	---	---	32.2	10.8	5.4	3.3	39.2	37.3
SYAL	0.4	---	---	---	26.8	2.0	3.9	0.3	4.8	2.76
CEVE	0.0	---	---	---	97.1	8.0	66.0			85.0
HODI	3.3	---	---	---	50.0	7.7	1.7	4.0	23.6	15.8
RUPA	16.0	---	---	---	---	---	---	---	---	3.7
RUBUS	5.0	---	---	---	---	---	---	---	---	---
VACCIN	9.7	---	---	---	---	---	---	---	---	---
LONIC	100.0	---	---	---	---	20.0	---	---	---	---
BEOC	---	---	---	---	10.0	---	---	---	---	---
SPBE	12.1	---	---	---	15.9	12.2	0.6	0.0	1.4	---
SHCA	0.0	---	---	---	0.0	3.3	2.2	10.0	---	40.0
CESA	---	---	---	---	---	29.1	73.3	6.0	---	---
SALIX	---	---	---	---	---	---	90.0	---	30.0	---
PRVI	---	---	---	---	---	---	30.0	2.1	35.6	33.3
POTR	---	---	---	---	---	---	70.0	---	---	20.0
PHLE	---	---	---	---	---	---	---	0.0	---	30.0
ACGL	0.0	---	---	---	---	---	---	---	---	20.0

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: East Sheep Creek

	Treatment					Control				
	Year					Year				
	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
Browse Species/ Percent Use										
CESA	---	---	---	53.3	55.0	54.4	83.3	---	16.0	70.0
SYAL	1.6	---	---	15.8	7.5	1.7	6.1	0.2	2.52	2.4
AMAL	5.9	---	---	44.4	---	6.0	51.9	4.1	31.5	27.3
SALIX	---	---	---	---	84.3	100.0	---	---	62.6	---
CEVE	0.0	---	---	---	---	15.0	80.0	---	90.0	---
HODI	10.0	---	---	30.4	21.2	17.7	7.1	1.4	21.0	22.3
ROSA	20.0	---	---	53.3	23.2	15.4	12.6	3.9	---	32.0
PHLE	---	---	---	---	87.5	13.3	---	---	42.1	53.3
PRVI	8.3	---	---	---	51.2	0.0	---	12.9	33.3	37.5
SPBE	17.7	---	---	14.1	9.0	14.2	2.6	0.5	2.0	4.4
GESA	33.0	---	---	---	---	50.0	---	---	---	---
SHCA	0.0	---	---	---	50.0	3.0	4.0	0.0	20.0	26.7
SALIX	83.0	---	---	71.4	---	---	---	---	---	---
ACGL	---	---	---	60.0	---	---	---	---	50.0	30.0
PHMA	---	---	---	71.1	48.3	---	---	---	---	---
RIBES	---	---	---	40.0	---	---	---	---	---	---
POTR	---	---	---	57.8	71.7	---	---	---	35.0	---
ALSI	---	---	---	---	---	---	---	---	---	4.4

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: West Sheep Creek

	Treatment					Control				
	Year					Year				
Browse Species/ Percent Use	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
AMAL	---	---	---	27.4	19.7	---	29.5	---	14.7	13.9
CEVE	---	---	---	---	---	---	72.2	---	45.6	22.0
SYAL	---	---	---	9.0	7.5	---	2.1	---	0.8	4.8
ROSA	---	---	---	38.7	65.0	---	3.5	---	24.0	16.0
PHLE	---	---	---	41.2	35.7	---	---	---	---	36.7
HODI	---	---	---	47.1	41.9	---	---	---	8.0	20.0
SPBE	---	---	---	1.5	8.2	---	---	---	0.6	2.0
PRVI	---	---	---	---	42.2	---	---	---	54.0	23.3
CESA	---	---	---	50.0	50.0	---	---	---	55.6	60.0
SHCA	---	---	---	40.0	---	---	---	---	30.0	25.0
SALIX	---	---	---	6.7	80.0	---	---	---	40.0	20.0
RUID	---	---	---	0.0	23.3	---	---	---	5.0	0.0
PHMA	---	---	---	28.9	---	---	---	---	41.4	---
POTR	---	---	---	61.7	53.3	---	---	---	---	---
ACGL	---	---	---	90.0	---	---	---	---	---	---
BEOC	---	---	---	50.0	30.0	---	---	---	---	---
RUPA	---	---	---	---	---	---	---	---	---	0.0

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: Rocky Gorge

	Treatment					Control				
	Year					Year				
Browse Species/ Percent Use	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
AMAL	11.9	20.1	8.3	23.8	23.7	17.4	47.9	15.5	19.8	14.1
ROSA	14.3	5.5	12.6	19.4	21.5	13.6	7.9	10.9	22.5	8.7
SYAL	6.3	7.8	5.4	1.4	1.7	5.0	5.0	0.8	2.9	0.5
SHCA	10.0	4.3	5.0	73.0	42.5	0.0	0.0	7.5	11.7	17.5
CESA	47.5	---	---	20.0	---	---	---	---	---	10.0
SPBE	9.5	0.3	1.6	3.1	3.1	22.7	0.4	---	1.8	1.9
SALIX	75.0	---	---	---	---	---	---	---	---	---
RUPA	100.0	---	---	---	---	---	---	---	---	---
POTR	---	---	---	30.8	27.4	20.0	---	---	10.0	34.6
CEVE	---	---	---	100.0	---	---	---	---	90.0	---
PRVI	---	---	---	30.0	---	---	---	---	---	---

Table 13(cont.). Browse utilization data from treatment areas from 1985 through 1989.

Transect Area: McGuire/Tweed Creeks

Browse Species/ Percent Use	Treatment				
	Year				
	'85	'86	'87	'88	'89
AMAL	---	3.1	---	---	13.0
SYAL	---	2.7	---	---	3.7
ROSA	---	4.9	---	---	6.4
SALIX	---	100.0	---	---	25.0
HODI	---	2.1	---	---	72.5
CEVE	---	30.0	---	---	---
SHCA	---	12.1	---	---	23.1
PRVI	---	0.0	---	---	10.0
ACGL	---	2.0	---	---	56.7
SPBE	---	1.3	---	---	7.1
PHLE	---	0.0	---	---	---
POTR	---	---	---	---	32.0
RUPA	---	---	---	---	20.0

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: Lower Stone Hill

	Treatment					Control				
	Year					Year				
	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
Browse Species/ Percent Use										
AMAL	3.9	41.6	2.9	15.4	24.8	2.1	60.0	6.9	21.0	17.3
ROSA	3.6	6.4	1.8	17.4	16.0	2.3	3.8	0.8	34.7	12.9
PUTR	1.2	11.8	0.0	34.9	21.3	1.5	3.1	0.1	26.3	27.8
CESA	55.6	85.4	3.7	61.9	63.3	40.0	71.2	---	69.2	---
CEVE	10.0	0.0	---	70.0	---	---	---	---	---	---
SYAL	0.0	1.5	0.0	0.0	0.9	2.9	0.1	0.0	3.10	0.6
SPBE	12.6	0.3	---	1.2	1.4	15.1	0.0	0.0	0.7	2.3
SHCA	0.0	1.2	---	40.0	34.0	0.0	0.0	0.0	---	23.3
PRVI	0.0	34.0	3.1	46.7	22.5	0.0	20.0	5.0	---	18.0
RUPA	---	---	---	---	---	5.0	---	---	---	---
SALIX	---	---	---	---	70.0	33.6	---	---	---	24.3
HODI	---	---	---	---	---	8.6	0.0	---	---	---
ACGL	---	---	---	---	---	0.0	---	0.0	70.0	0.0
POTR	---	---	---	23.3	45.0	---	---	---	8.0	10.0
BEOC	---	---	---	---	---	---	---	---	10.0	---
PHLE	---	---	---	---	---	---	---	---	---	20.0

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: North Stone Hill

	Treatment					Control				
	Year					Year				
Browse Species/ Percent Use	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
AMAL	14.9	39.2	---	24.4	32.9	11.7	35.5	---	22.5	29.1
ROSA	14.6	2.6	---	10.7	---	13.3	2.1	---	---	8.3
SHCA	1.1	0.08	---	11.2	5.9	0.0	0.3	---	5.0	38.1
PHLE	5.0	---	---	0.0	0.0	5.00	---	---	2.0	---
SALIX	46.1	55.2	---	26.7	50.0	34.8	59.0	---	28.8	---
RIBES	5.0	---	---	---	---	---	---	---	---	6.7
CEVE	2.0	45.4	---	42.0	58.2	4.0	53.7	---	33.1	57.5
CESA	41.2	47.2	---	68.9	69.4	46.2	66.7	---	48.1	53.7
SYAL	3.3	0.0	---	0.0	---	2.0	0.0	---	0.6	0.4
SPBE	5.7	0.0	---	1.3	1.4	5.4	0.4	---	1.8	1.2
PUTR	2.0	1.4	---	---	25.0	4.0	1.2	---	27.6	19.4
PHMA	0.0	0.0	---	10.0	10.0	3.0	---	---	2.6	10.0
RIVI	---	---	---	---	---	0.0	0.0	---	---	---
RUBUS	---	---	---	---	---	20.0	---	---	---	---
HODI	---	---	---	0.0	---	---	---	---	10.0	16.7
PHLE	---	---	---	0.0	---	---	---	---	---	---
POTR	---	---	---	---	15.9	---	---	---	28.8	42.0
POTRI	---	---	---	---	65.5	---	---	---	---	---

Table 13(cont.). Browse utilization data from treatment and paired control areas from 1985 through 1989.

Transect Area: Stone Hill Fertilization

	Treatment					Control				
	Year					Year				
Browse Species/ Percent Use	'85	'86	'87	'88	'89	'85	'86	'87	'88	'89
CESA	---	56.7	0.0	58.7	12.5	---	50.8	---	55.0	---
SALIX	---	63.7	---	66.5	33.5	---	50.0	---	3.7	---
AMAL	---	44.6	11.8	52.1	27.9	---	41.3	---	24.4	---
PHMA	---	4.0	---	4.1	12.7	---	3.8	---	1.1	---
PUTR	---	3.3	0.0	34.4	23.7	---	4.3	---	27.5	---
PHLE	0.0	---	---	---	20.1	---	1.7	---	2.9	---
SHCA	0.0	0.0	---	---	---	---	---	---	---	---
SPBE	0.9	0.0	2.8	5.7	---	---	2.0	---	0.4	---
PRVI	---	---	6.4	---	---	---	10.0	---	---	---
RUBUS	---	---	---	10.0	---	---	---	---	0.0	---
CEVE	---	---	---	70.0	---	---	---	---	---	---
HODI	---	---	0.1	---	---	---	---	---	---	---
RIBES	---	---	---	10.0	10.0	---	---	---	---	---
POTR	---	---	---	---	34.0	---	---	---	---	---
RUID	---	---	---	---	30.0	---	---	---	---	---

APPENDIX B

Pellet Group Summaries

Table 14. Pellet group transects on study area analyzed from 1985 to present.

Transect Area	Period	$\bar{X}$/plot	SD	$\bar{X}$/hectare	N
Tenmile Treatment	Summer '85	0.15	0.366	37	20
	Spring '89	14.05	7.522	3472	20
	Summer '90	7.90	7.649	1952	20
Tenmile Control	Summer '85	0.10	0.308	25	20
	Spring '86	1.40	1.142	346	20
	Summer '86	3.22	5.512	796	40
	Spring '87	0.45	0.999	111	20
	Spring '88	3.65	2.870	902	20
	Spring '89	3.10	2.634	766	20
	Summer '90	5.70	8.151	1408	20
Sheep Creek East Trtmt.	Spring '88	7.35	5.324	1816	20
	Spring '89	12.30	5.555	3039	20
Sheep Creek East Cntrl.	Summer '85	0.30	0.571	74	20
	Spring '86	0.95	0.991	235	20
	Summer '86	3.95	3.979	976	20
	Autumn '86	1.60	2.371	395	20
	Spring '87	0.25	0.550	62	20
	Spring '88	3.45	2.665	852	20
	Spring '89	5.05	3.203	1248	20
Sheep Creek West Trtmt.	Spring '88	4.80	3.874	1186	20
	Summer '89	8.70	5.844	2150	20
Sheep Creek West Cntrl.	Summer '85	0.10	0.308	25	20
	Spring '86	0.95	0.999	235	20
	Summer '86	4.90	5.015	1211	20
	Spring '88	3.05	2.481	754	20
	Summer '89	2.85	1.935	704	20
Rocky Gorge Treatment	Summer '85	1.30	1.867	321	20
	Summer '86	4.96	5.444	1226	45
	Spring '87	2.07	1.817	511	40
	Summer '88	6.00	4.180	1483	20
	Summer '89	7.25	4.050	1791	20
Rocky Gorge Control	Summer '85	0.65	0.933	161	20
	Summer '86	6.40	3.169	346	10
	Spring '87	1.35	1.477	334	40
	Summer '88	4.00	2.809	988	20
	Summer '89	2.55	2.195	630	20

Table 14 (cont.). Pellet group transects on study area analyzed from 1985 to present.

Transect Area	Period	$\bar{X}$/plot	SD	$\bar{X}$/hectare	N
Mcguire/Tweed Treatment	Summer '86	2.80	2.348	692	10
	Autumn '86	1.40	1.075	346	10
	Summer '88	2.30	2.359	568	10
	Summer '89	2.90	1.945	717	20
Lower Stone Hill Trtmt.	Summer '85	0.20	0.410	49	20
	Summer '86	3.52	2.449	870	40
	Autumn '86	10.55	6.403	2607	20
	Summer '87	0.60	1.057	148	40
	Summer '88	8.15	4.056	2014	20
	Summer '89	8.05	5.725	1989	20
Lower Stone Hill Cntrl.	Summer '85	0.05	0.224	12	20
	Summer '86	2.77	3.548	684	40
	Autumn '86	4.35	2.661	1075	20
	Summer '87	0.75	0.927	185	40
	Summer '88	4.70	3.526	1161	20
	Summer '89	6.95	5.566	1717	20
North Stone Hill Trtmt.	Summer '85	1.25	2.179	309	12
	Summer '86	2.77	1.954	685	40
	Autumn '86	3.35	2.769	828	40
	Summer '87	4.22	3.591	1043	40
	Summer '88	4.30	3.532	1063	30
	Summer '89	3.35	3.275	828	20
North Stone Hill Cntrl.	Summer '85	0.50	0.548	124	6
	Summer '86	1.80	1.508	445	20
	Autumn '86	3.85	2.641	951	20
	Summer '88	3.45	2.164	852	20
	Summer '89	2.20	1.705	543	20
Stone Hill Fert. Trtmt.	Summer '86	0.85	0.988	210	20
	Autumn '86	1.70	1.418	420	10
	Spring '87	1.70	1.302	420	20
	Summer '87	0.80	0.768	198	20
	Summer '88	4.70	2.980	1235	10
	Summer '89	3.45	2.985	852	20
Stone Hill Fert. Cntrl.	Summer '86	1.80	1.549	445	10
	Autumn '86	0.80	0.632	198	10
	Spring '87	0.70	0.438	173	10
	Summer '87	1.10	1.197	272	10
	Summer '88	4.00	1.886	988	10
	Summer '89	2.00	1.765	494	10

APPENDIX C

Herbaceous Plant Production

Table 15. Herbaceous plant production (kg/ha) on treatment and paired control areas, 1985 to 1990.

Area	1985	1986	1987	1988	1989	1990
Tenmile Treatment						
Grass	244				1035	379
Forb	137				539	176
Other	44				0	0
Tenmile Control						
Grass	276	286			81	276
Forb	69	299			168	85
Other	4	21			7	0
East Sheep Cr. Treatment						
Grass				350	1119	
Forb				963	1134	
Other				0	0	
East Sheep Cr. Control						
Grass	164	160		69	134	
Forb	178	256		97	323	
Other	28	211		0	Tr	
West Sheep Cr. Treatment						
Grass				562	1062	
Forb				238	421	
Other				0	0	
West Sheep Cr. Control						
Grass	158	247		172	149	
Forb	112	153		224	229	
Other	2	107		0	0	

Table 15 (cont.). Herbaceous plant production (kg/ha) at treatment and paired control areas, 1985 to 1990.

Area	1985	1986	1987	1988	1989	1990
Rocky Gorge Treatment						
Grass	466	360	214	476		
Forb	536	975	844	979		
Other	12	406	0	0		
Rocky Gorge Control						
Grass	431	538	352	276		
Forb	660	1230	584	626		
Other	23	82	0	0		
McGuire/Tweed Treatment						
Grass		224		770		
Forb		34		169		
Other		110		0		
Lower Stone Hill Treatment						
Grass	358	578	1144	850		
Forb	82	135	249	646		
Other	34	356	0	0		
Lower Stone Hill Control						
Grass	183	554	429	275		
Forb	178	498	133	386		
Other	23	39	0	0		
North Stone Hill Treatment						
Grass	910	670		523	553	
Forb	116	210		225	278	
Other	204	38		0	Tr	
North Stone Hill Control						
Grass	440	285		309	326	
Forb	202	53		133	105	
Other	6	0		0	0	

Table 15 (cont.). Herbaceous plant production (kg/ha) at treatment and paired control areas, 1985 to 1990.

Area	1985	1986	1987	1988	1989	1990
Stone Hill Fert. Treatment						
Grass		614	1038	655		
Forb		292	66	162		
Other		1728	0	0		
Stone Hill Fert. Control						
Grass		823	360	685		
Forb		708	556	133		
Other		0	0	3		